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ABSTRACT

Driving while intoxicated causes many traffic accidents and deaths. Two decisions are closely related, whether to engage in heavy drinking, and to drive, conditional on heavy drinking. This paper reviews the extensive literature on heavy drinking, addiction, and driving after heavy drinking. Relevant public policies involve a combination of deterrence, incapacitation, and treatment. While there is empirical support for the rational addiction model applied to heavy drinking, some attributes of drinker-drivers differ from others (e.g., impulsivity in domains other than alcohol consumption, hyperbolic discounting). Policies most effective in reducing drinking and driving are alcohol excise taxes, minimum drinking age and zero tolerance laws for underage persons, dram shop and social host liability, and criminal sanctions overall. Empirical studies have not determined which specific criminal sanctions are most effective. A major impediment to criminal sanctions as a deterrent is that the probability of being stopped/arrested when driving while intoxicated is extremely low, < 0.01 to 0.02 at most, further reduced by probability of conviction/sentencing following stop/arrest far below 1. Incarceration lengths tend to be too short to incapacitate people from drinking and driving. Alcohol treatment's effectiveness is limited by low treatment rates among persons for whom treatment is appropriate.

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High levels of alcohol consumption have been associated with a variety of adverse outcomes of which driving while intoxicated (DWI) and traffic-related injuries, the subject of this chapter is only one of the more important ones: cancers, particularly liver cancer; cardiovascular disease, stroke, cirrhosis of the liver, and other injuries including self-inflicted injuries and homicides and other criminal acts (Room et al., 2005; Hansen and Waddell, 2018).

Even considering that excessive use of alcohol is a public health hazard for reasons other than the risks it poses to traffic safety, driving while intoxicated is an extremely important harm in its own right. In 2016, about 10,500 persons died in alcohol-impaired crashes—28 percent of all traffic-related deaths. Over a million drivers were arrested on a charge of DWI that year (for both alcohol and narcotics). In 2006, there were an estimated 116 million drunk driving episodes in the US. The high rate of drunk driving episodes relative to the number of DWI charges suggests that the probability of an arrest for DWI per DWI episode is under 0.01. As indicated later, reports of this probability range up to 0.02. Fortunately, the number fell to 111 million by 2014, the latest year for which drunk driving episode data are available from the US Centers for Disease Control (US Centers for Disease Control, 2020).

The objective of this review is to present empirical evidence on behaviors that underlie the decision to drive under the influence of alcohol. The intended audiences are researchers and public policy makers, especially those policy makers who want to dig beneath the headlines of the extent of the problem and capsule descriptions of findings of particular policies. There have been earlier reviews of the empirical evidence on drinking and driving (Benson et al., 1999) and more general reviews of health behaviors which include alcohol consumption and its harms. This review is both more recent and focused on a larger range of public policy options. driving under the influence of alcohol. Emphasis reflects the author's background as a card-carrying economist and three decades of research on the chapter's topic. One reason for the focus on economic studies is that the literature on alcohol use and its harms in general and driving under the influence of alcohol and its harms is vast. There are far too many studies to cover adequately in a single review, except perhaps superficially.

This chapter is divided into broad sections. The first is a discussion of conceptual frameworks which have been used by economists to study alcohol consumption, heavy drinking, and DWI. The next section presents empirical evidence on the validity of the assumption that drinking and driving is a rational choice, and econometric approaches that have been used to

evaluate the effectiveness of public policies to reduce the number of drinking and driving episodes and their resulting harms. Policies are designed to reduce drinking and driving and control excess drinking by a combination of deterrence, incapacitation of persons thought to be incapable of making rational choices—either because of their age or their level of intoxication, and rehabilitation or treatment. Relevant policies range from criminal laws to civil laws and insurance, to those promoting or requiring treatment of persons who regularly consume high levels of alcohol and/or drink and drive.

Theory

Terminology

Two behaviors are involved in driving while intoxicated: heavy or binge drinking; and the decision to drive conditional on being impaired due to high levels of alcohol use or binge drinking. Heavy drinking is a general term. Binge drinking is more specific. It is defined, as consuming 5+ drinks on a single occasion for men and 4+ drinks/occasion for women and sometimes 5+ drinks/occasion for both sexes, is not necessarily the result of an addiction to alcohol (Tomberg, 2010), although binge drinking occurs more frequently among alcohol addicts. Naimi et al. (2003) found that binge drinkers are 14 times more likely to drive while impaired by alcohol compared with non-binge drinkers.

Heavy/Binge Drinking and Driving While Intoxicated as Rational Choices

Although at first glance, heavy drinking, being addicted to alcohol, and drinking under the influence of alcohol, would appear to be irrational decisions, reflecting myopia—failure to fully consider long-run consequences of current choices, as well as lack of self-control, roughly since the late 1960s, mainstream economists have assumed that individuals are rational and forward-looking even in choices that involve potential personal harm. In this framework, a decision maker weighs the benefits against the short- and long-run adverse consequences of the individual's choice. It follows that given that driving under the influence of alcohol is a crime, the decision to drink and drive can be analyzed like as any decision as to whether or not to commit a crime. The crime is DWI, not heavy drinking per se. Gary Becker's (1968) seminal paper on the economics of crime assumes that potential criminals are expected utility maximizers, based on assumptions these decision-makers are rational and forward-looking. The individual computes expected utility from each choices and selects the option for which expected utility is highest.

In the context of drinking and driving, expected utility represents the difference between the discounted utility of high levels of alcohol consumption, i.e., the utility of getting drunk, which tends to decline immediately and discounted utility of the costs of the combination of alcohol consumption and driving after having had too much to drink, most of which occur downstream.

Benefits reflect the marginal utility of a drink and marginal utilities of other aspects of the consumption decision, such as from socializing, boasting how much alcohol one can consume at a sitting, and the like. Negative marginal utilities come from the price of the drink, possible adverse health effects, both in the short run, e.g., from immediate costs of an accident or being charged with a DWI, as well as adverse long-run health effects such as from physical impairments and from penalties imposed subsequently. An example of an option to driving while intoxicated is to obtain a designated driver or hire a commercial driver, but these too involve costs to the individual.

Costs in particular are uncertain. Thus, costs are weighted by the probability that an event will occur. As already noted, the probability that a drunk driver is stopped and criminally charged is very low. And given an arrest, drunk drivers face uncertain outcomes from the arrest—probabilities of prosecution, conviction, and a variety of criminal sanctions that may or may not be imposed. Since all of these adverse outcomes to the drunk driver have probabilities far less than one, expected cost (expected utility loss) is reduced accordingly. Thus, the expected value of minimum jail time for first DWI of 24 hours would be 7.2 minutes to the driver if the probability of being stopped and arrested for DWI is 0.01 and the probability of jail time conditional on an arrest is 0.5. Admittedly there are other costs such as the stigma of being incarcerated at all.

Although benefits and some adverse effects of drunk driving are immediate, e.g., the cost of an emergency room visit or repair of the vehicle following an accident, other costs are long-term, such from work loss due to a permanent disability. The role of discounting is given higher weight to expected benefits and costs accruing immediately.

The decision to drive while intoxicated can be split into two parts. Then there are four combinations (Figure 1). In cell 1, decision-makers are rational and forward-looking in both. In cell 4, they are irrational and myopic in both. In cell 3, people are rational and forward-looking in the decision to drive once intoxicated, but not in deciding whether to engage in heavy

drinking. This seems the least likely a priori unless the principal has the foresight to arrange for a designated driver or lodging for the night in advance, but is not a planner when it comes to heavy drinking. In cell 2, the individual may have the foresight to know that rational decision-making will be difficult when intoxicated, i.e., the individual may be a “sophisticate” (Gruber and Koszegi, 2001), having the foresight to make plans for rides and/or lodging in advance of the drinking episode. The cost associated with heavy drinking would then include the cost of a taxi or a night at a hotel, for example. If belonging in cell 2 but without such foresight (“naifs”), the rational heavy drinking would consider the cost of the various adverse outcomes from drinking and driving in the decision to engage in heavy drinking. Mention of sophisticates and naifs anticipates the discussion of behavioral economics below.

		<u>Rational drinking-driving?</u>	
<u>Rational Heavy drinking?</u>		yes	No
	yes	1	2
	no	3	4

Figure. 1. Are People Rational and Forward-Looking in the Drinking Domain?

Alcohol addicts are heavy drinkers but not all heavy drinkers are addicted to alcohol. Becoming addicted as a rational choice has been modelled in a classic paper by Gary Becker and Kevin Murphy (Becker and Murphy, 1988). In particular, the *marginal utility* of current consumption is not constant, but rises for people with greater histories of past drinking—higher addictive stock (due to reinforcement and the costs of withdrawal) while the *utility* of the addictive stock is negative, i.e., being addicted is a bad.

The Behavioral Economics Critique in this Context

The assumption that people are rational and forward-looking expected utility maximizers has come under attack. Economists have joined the attack with the evolution of “behavioral economics,” a field that predominantly draws from psychology. In brief, behavioral economics questions whether: (1) individuals are capable of adequately evaluating the full range of alternative options at the same time—bounded rationality (Simon, 1991)); (2) individuals’ subjective probabilities of adverse consequences of harmful behaviors are unbiased (or conversely overly optimistic, Weinstein, 1980); (3) people use constant discount factors for computing present values of benefits and costs (exponential discounting) versus smaller discount factors when computing long-run benefits and costs than for benefits and costs accruing in the

short-run following implementation of a decision (hyperbolic discounting, Frederick, et al., 2002); and (4) many decisions are guided by cold calculations without a role of emotions in decision-making (Loewenstein, 1996; Loewenstein et al., 2001).

An intoxicated person's ability to calculate the utility of a range of options may be limited by the person's intoxicated state. Optimism bias may lead people to unrealistic subjective beliefs of adverse outcomes stemming from heavy drinking and driving while intoxicated. Since benefits of these activities are realized immediately while some costs accrue much later, exceptions being the immediate cost of an accident or an arrest for DWI leading to a night in jail, hyperbolic discounting may make people more prone to heavy drinking and drinking and driving than would occur under exponential discounting; furthermore, decisions to engage in heavy drinking and drinking and driving may have a large emotional component.

Many uncertain outcomes underlie the act of drinking and driving, including the probability of having an accident resulting in a probability distribution of injury severities to self and others; the probabilities of being stopped by police, and if stopped, the probability of being charged with a DWI. To be charged, a breathalyzer done in the field must show a blood alcohol content (BAC) reading above a threshold specified in a statute. People may feel somewhat intoxicated but not know whether their BAC exceeds the threshold. Then if charged, the prosecutor has to decide whether to prosecute. Then there is the probability that plea bargaining will result in a lesser charge than a DWI. Judges decide whether to convict or not, followed by sentencing conditional on a conviction. Parole and probation officers *may* subsequently reduce penalties imposed at sentencing. That objective probabilities differ from subjective probabilities is not at all surprising. Yet when researchers compare survey respondents' subjective probabilities with their objective counterparts, it is possible that respondents are likely to have private information not available to outsiders, including researchers.

The issue is not as much inaccuracy of subjective probabilities but in their bias. Whether or not optimism bias is common in the context of drinking and driving cannot be deduced but rather must be inferred from the empirical evidence. Likewise, whether or not people are exponential or hyperbolic discounters in deciding on whether to drive while intoxicated should not be inferred from anecdotes but rather from rigorous empirical tests.

Theories of rational behavior as applied to health behaviors and the behavioral economics critique and the decision to engage in criminal activity have been well-described elsewhere (e.g.,

Rabin, 1998; Gigerenzer and Selten, 2002; Ehrlich, 2010; Cawley and Ruhm, 2012). Trying to demonstrate that people are rational or irrational in their decision-making as a general matter is a fruitless task. Rather the focus in this chapter is on decision making in the specific context of drinking and driving.

The Relationship of Rational versus Irrational Decision-Making and Choice of Public Policies to Reduce Rates of Driving While Intoxicated and its Consequences.

Whether people are rational decision-makers in deciding whether to drink and drive should affect the flavor of public policy recommendations. To the extent that heavy drinking and drinking and driving are rational choices, effective policies are likely to involve prices, including prices of alcoholic beverages and general deterrent effects of criminal and civil law sanctions, both the probabilities of drunk driving law enforcement, and sanctions based a judicial finding that a criminal act has been committed. General deterrence represents the impact of the threat of legal punishment on the public at large and specific deterrence, the impact of the actual legal punishment on those who have been apprehended.

If such choices are imperfectly or not rational, effective public policies should focus on restricting individuals' options. Such controls range from legal restrictions on the age at which individuals can purchase alcoholic beverages, on hours and place of sale of alcoholic beverage to various forms of incapacitation, such as ignition interlock devices which prevent persons with a blood alcohol content (BAC) level above the legal limit from operating a motor vehicle, to imposing tort liability on alcohol sellers and social hosts for serving obviously intoxicated adults or underage patrons, to extending minimum incarceration lengths of convictions on a DWI charge. Compulsory alcohol treatment is also an option in such cases.

Empirical Analysis: An Overview

The Assumption of Rational Choice

If one asked legislators, prosecutors and judges, administrators charged with executing public policies related to drinking and driving, and/or members of the public at large whether or not the decision to drink and drive reflects a rational choice, the vast majority of respondents would reject the notion of rational choice in this context. But many of the public policies that are implemented by law or regulation implicitly assume people are rational in their drinking, e.g., laws increasing the mandatory minimum sentence length. Such opinions are not trustworthy. Empirical evidence using best-practice methodologies is needed.

Becker and coauthors (1994) and others (e.g., Dumuyck and Verriest, 2013; Jones et al., 2018) found empirical support for the rational addiction model, including evidence that prices of addictive goods, including future prices affect current consumption of cigarettes. One might infer from this evidence that people are rational and forward-looking in the alcohol consumption domain as well.

Studies applying the rational addiction model to alcohol use have been relatively rare. Waters and Sloan (1995) empirical analysis found “relatively strong support” for the rational addiction model. In particular, coefficients on past, present, and future money prices and fines for a first DWI conviction were statistically significant with signs predicted by the rational addiction model. Subsequently, Baltagi and Griffin (2002) found empirical support for this model for liquor consumption. Tests of the rational addiction model have been criticized, both in terms of the adequacy of the empirical tests and the underlying assumptions (see in particular, Gruber and Koszegi, 2001, and Auld and Grootendorst, 2004).

Becker (1968) presented some evidence that the decision to commit a crime is a rational choice. That individuals are rational and forward-looking is generally assumed in empirical economic studies of this behavior. Ironically, this is also implicitly assumed by the public and by public officials who advocate some of the most popular “solutions” to the drinking and driving problem. Raising excise taxes on beer should boost beer prices and lead rational consumers to substitute consumption of beer with other goods and services. In Becker and Murphy’s rational addiction model, increases in future prices of addictive goods negatively affect current consumption of such goods (Becker et al., 1994). Policies designed to deter drinking and driving, such as higher minimum criminal sanctions on drinking and driving, rely on an assumption that by raising the cost of drinking and driving, many people will decide to eschew drinking and driving. The focus of empirical analysis has not been on validity the rational behavior assumption, but rather to assess the effectiveness of specific public policies on drinking and driving behavior. There is some recent empirical evidence on this matter to be described below.

Econometric Issues in Evaluating the Effects of Drinking and Drinking Policies

The gold standard for evaluating the effect of an intervention is the randomized controlled trial (RCT). In an RCT of a new cancer drug, patients with a specific type of cancer are randomized to a treatment or control group. Ideally, neither patients or their physicians know to which group individual patients are assigned. The only voluntary decision of individual patients

is whether to volunteer to participate in the experiment at all. RCTs have problems, e.g., dropouts from the experiment (see e.g., Philipson and Hedges, 1998), but compared to problems in evaluating drinking and driving policies, RCTs' problems are minor.

Some drinking and driving policies have properties that make them amenable to evaluation by an RCT, but they are in the minority. For example, following conviction for driving while intoxicated (DWI), a judge may order use of an ankle bracelet (Secure Continuous Alcohol Control Monitoring or SCRAM device) which monitors BAC or use of ignition interlock in which a device prevents the motor vehicle from starting when it detects alcohol vapors indicating alcohol consumption. It is possible to randomized persons into SCRAM devices or ignition interlock devices, although not to double-blind. Even in this case, there is some question of the external validity of the findings in that a law making it legal to implement such devices does not guarantee that the judge will require such monitoring conditional on a conviction for DWI. Wearers could disable such devices. In an RCT, they may promise not to do this. In the "real world," prosecutors and judges are likely to consider downstream penalties in their prosecution and conviction decisions.

For most public policy options aiming to reduce rates of drinking and driving, conducting an RCT is infeasible. It would be unethical to randomize convicted individuals to incarcerations of varying lengths or fines of varying amounts. Unannounced police roadblocks used to screen drivers for their BACs might work, but the external validity of the findings is questionable. Many roadblocks are predictable with respect to location, time or day of week, and holidays. GPS systems can warn drivers of traffic congestion down the road.

Even absent these concerns, RCTs are prohibitively expensive and with few important exceptions (e.g., health insurance, negative income tax) have not been implemented to answer questions in the social sciences on more than a localized basis. Thus, social science researchers in general and researchers on drinking and driving have mainly used observational data.

The major issue with analysis of observational data is endogeneity of decision making. This issue is important in studies of drinking and driving behavior. For one, laws designed to curb drinking and driving or increase the probability of DWI arrest are more likely to be implemented in areas in which the drinking and driving problem is considered to be more adverse, either because people are more likely to drink and drive or for other reasons, such as differences in preferences of the population in the locality, e.g., in religious beliefs related to

alcohol use. Thus, it is difficult to distinguish the true effect of the policy from the context in which the decision to enact the law is made and is executed.

These econometric issues are hardly unique to drinking and driving. Applied economists use various approaches to deal with endogeneity: inclusion of covariates designed to capture the variation in likely causes of endogeneity in the public policy covariates; use of a panel design with area and time fixed effects; instrumental variables (IVs); and regression discontinuity design (RDD). Even after accounting for omitted heterogeneity, the parameter estimates on policy covariates represent mean effects.

In addition, there is multicollinearity among the covariates used to measure specific public policies and the heterogeneity of effects of individual policies. Multicollinearity arises because many policies are enacted at the same time, reflecting constituent perceptions and/or (in the US), a Federal law which requires or incentivizes action by individual states.

Panel methods using area and time fixed effects are useful for accounting for omitted heterogeneity which is the source of endogeneity, but the method requires both interarea and intertemporal variation in policies. Use of RDD and IV methods are limited to analysis of one policy option at a time. Satisfying the conditions for a valid IV is a challenge, but not unique to this context.

The most direct dependent variable is a measure of drunk driving frequency. However, this measure is only available by self-report. Typically, surveys have asked respondents how often they have elicited how often they drove after having too much to drink. Examples of such surveys are the Health Promotion and Disease Prevention (HPDP) supplement to the 1985 Health Interview Survey, Behavioral Risk Factor Surveillance Surveys (BRFSS), conducted nationally by the US National Center for Health Statistics, National Epidemiologic Survey of Alcohol and Related Conditions (NESARC), and the Survey of Alcohol and Driving (SAD) conducted in eight US cities throughout the US, conducted under this author's direction.

Two types of errors seem likely from these self-reports. First, given the stigma of heavy alcohol use and drunk driving, these behaviors may be underreported. Second, unless a breathalyzer test was administered, the respondent only knows "too much to drink," not whether the BAC exceeded the threshold for a DWI. Using the HPDP, Kenkel (1993) estimated that there were about 134 instances of drunk driving in 1985, compared to 1.5 million arrests, which implies an offence to arrest ratio of 90:1. Wilkinson's (1987) estimate is 50:1, which implies the

probability of being arrested for DWI conditional on drinking and driving is 0.02. The probability reported above was even lower.

Although drunk driving frequency is the most direct measure, other measures have been widely used, including alcohol-related traffic fatalities, traffic fatalities—mainly because data on alcohol-related traffic fatalities are not available at all in earlier years, and then only for some states. Dependent variables have also been defined for alcohol related deaths, not limited to traffic fatalities and deaths from non-traffic-related causes other than from alcohol consumption. While these might seem like indirect measures of drunk driving, they reflect the motivation for implementing and enforcing drunk driving laws—to reduce the societal cost of heavy drinking and drinking and driving.

How Researchers Have Dealt with the Econometric Issues: Some Examples

Analysis of Single Cross Sectional and Panel Data. In a highly-cited study, Kenkel (1993) used data from a single cross-section, the HPDP, to assess the impact of implementation of state laws designed to deter drinking and driving. The observational unit was the individual HPDP respondent. The use of a single cross-section precluded use of panel data methods. Rather the author included covariates to capture heterogeneity that, if not accounted for, would lead to endogeneity of the policy covariates. These covariates were demographic characteristics, income, employment status, and stress levels of the respondent.

Kenkel specified a two-equation model with HEAVY, the number of days with 5+ drinks in the past year, and driving under the influence (DUI), the number of occasions of drunk-driving in the past year, the two dependent variables. HEAVY was included as a covariate in the DUI equation. The author described his framework as recursive. This implies that he assumed that the person first decides on whether to drink excessively on a day and conditional on this, the person then decides whether to drive while intoxicated. (Sloan et al. (1995) also analyzed binge drinking and driving under the influence. Results were similar to Kenkel's).

Kenkel's identification strategy was to exclude variates alcohol-control policy covariates from the DUI equation. These covariates, defined by state, were a composite measure of alcohol price, a measure of the individual's health knowledge, whether the state was a monopoly alcohol state (the state ran its own liquor stores), the difference between the individual's age and the state's minimum drinking age, and a binary for whether or not the state bordered on a state with

a lower minimum drinking age. The minimum drinking age affects sales of alcohol, but in several states, this law also includes zero BAC thresholds for a DWI charge issued to youths.

Policy covariates to measure laws to reduce driving under the influence were: mandatory jail term or community service for first offense; administrative per se license suspension; law to allow police to perform a preliminary breath test for alcohol at the traffic stop; law to allow for sobriety checkpoints, and anti-plea bargaining laws which constrain the use of plea bargains in cases in which the person was initially charged with drunk driving, and laws establishing mandatory punishment for the first offence. These laws do not exhaust all statutes enacted to reduce drunk driving, e.g. civil laws, a possible source of omitted variables bias.

Also, a point applicable to all of the multistate studies, there is heterogeneity in the laws among states, both in their content and in their implementation. For example, a law to permit sobriety checks does not indicate how often they are performed. There is variation, for example, in anti-plea bargaining statutes (NCSL, 2017). At best, studies using single cross sections or even panel data can yield *mean* effects of implementing state policies.

The only US panels for analysis of drinking and driving are BRFSS and NESARC. Chaloupka et al. (1993) used panel data on motor vehicle fatalities to population per state/year). In addition to state laws and state and year fixed effects, they included covariates for state-level preferences, per capita income, and characteristics of driving (e.g., percent driving over the 65 mile per hour speed limit). Use of time and fixed effects accounted for intertemporal and persistent interstate variation not accounted for by the measures of preferences, driving, and income. They showed results with difference specifications and with and without state fixed effects. Use of fatality data at the state and year level allowed for use of panel data methods. Ruhm (1996) also conducted an analysis of motor vehicle fatalities using panel data., finding that some of the potentially important results were sensitive to the presence of state fixed effects. *Instrumental Variables*. Requirements for valid IVs is (1) that exclusion restrictions be valid and (2) IVs be strongly related to the endogenous variables. In Kenkel (1993), identification was designed to be achieved by excluding certain laws from the DUI designed to reduce drinking and driving. But laws included in both equations may have been endogenous. It seems likely that states in which constituents perceive that heavy drinking and drunk driving are societal problems would be the first to enact such criminal sanctions.

Even though IVs are widely used in applied studies, examples of their use in this context are rare since typically a host of public policies have been evaluated in a single study, making an IV approach infeasible. Sloan et al. (2016) used court data in electronic form from North Carolina to assess the effect of being prosecuted or convicted on a DWI charge on the probability of re-arrest on a DWI charge. ((Additional detail was available from paper records but accessing these would have required visits to each of 100 counties in the state.) The observational unit was an arrest for DWI. They specified a two-equation model. In the second stage, the dependent variable was the probability of re-arrest during follow-up. In the first stage, the dependent variable was the probability of being prosecuted or alternatively, for those persons prosecuted, the probability of a conviction. The key study hypotheses were that persons who are prosecuted and conditional on being prosecuted, were convicted, were less likely to be re-arrested on a DWI charge during the follow-up period. (specific deterrence).

Being prosecuted or being convicted were, alternatively, endogenous explanatory variables in the second stage. Endogeneity arises here because whether a prosecutor declines to prosecute or a judge decides to acquit depends in part on the strength of the evidence, prior convictions, and attributes of the defendant, none of which were accurately observed or observed at all in electronic court record. A person with clear evidence of having committed a DWI, with a prior criminal record, and other attributes associated with recidivism not observed by the researcher but observed by persons involved in the criminal justice system is more likely to be prosecuted and convicted and to be re-arrested. Without accounting for these important sources of such unobserved heterogeneity among arrestees, the observed relationships between prosecution and conviction and recidivism not causal.

The IV in the first stage of the analysis of effects of being prosecuted was the mean prosecution rate for DWI cases of the arrestee's prosecutor relative to the prosecution rate of all DWI cases in the judicial district. (Prosecutorial districts almost always coincided with judicial districts.) This IV measured the stringency of the prosecutor. For the analysis of the effects of conviction, the IV was the mean conviction rate in DWI cases of the judge who heard the individual's case relative to the mean conviction rate of judges in the judicial district. Differences in means were used given that the analysis also accounted for district fixed effects. Results from the first stage clearly indicated that the IVs were not weak. With one IV, the authors could not conduct overidentification tests.

A similar approach has been used to study effects of child placement in foster care on child behavior and on behavior of adults who were placed in foster care as children ((Doyle 2007, 2008) and effects of juvenile incarceration on subsequent criminal behavior (Aizer and Doyle, 2015).

Francesconi and James (2019) used a two-sample instrumental variables estimation procedure previously employed by Angrist and Krueger (1992) and Arellano and Meghir (1992). They specified a two-equation model. The first stage equation had binge drinking as a dependent variable. In the second stage, dependent variables were various adverse outcomes of binge drinking. The instrument was an interaction term between age (young versus old) and day of the week. The instrument was designed to pick up different drinking patterns for young versus old persons by day of the week. The authors performed the usual tests for instrument validity, finding that the instrument (actually several interaction terms) was valid.

Regression Discontinuity Design. Regression discontinuity design (RDD) has been used in a variety of applications, such as for assessing impacts of health insurance coverage using the fact persons first become eligible for Medicare at age 65 (Card et al., 2009). RDD circumvents the problem of finding valid IVs.

Hansen (2015) used data on traffic stops from the state of Washington to determine the extent to which an arrest on a charge of DWI— $BAC \geq 0.08$ or aggravated DWI— $BAC \geq 0.15$. reduced the probability of a re-arrest on a DWI charge during the follow-up period. The 0.08 and 0.15 thresholds are ideal for using RDD since drivers cannot know precisely what their BACs are prior to testing and neither can police officers. Rather the precise BAC is determined by a breathalyzer test immediately following the traffic stop. Even though this argument seems convincing, Hansen conducted statistical tests to determine whether RDD was appropriate for his analysis. He looked for bunching around the BAC thresholds which, if present, may reflect manipulation of the test results. He examined whether observables, e.g., whether the BAC was measured following an accident, and demographic characteristics of drivers, were unchanged across the BAC thresholds. Like Sloan et al. (2016), Hansen found evidence of specific deterrence. Having a BAC above the thresholds by two percentage points for the 0.08 BAC threshold, a 17 percent reduction, and by an additional percentage point for the drivers exceeding the 0.15 BAC threshold.

Empirical Evidence on Departures from Rationality in the Decision to Drink and Drive

One test of the premise that people are rational and forward-looking in the decision to drink and drive is to determine whether laws designed to reduce drinking and driving are effective. Kenkel (1993) found that overall imposing criminal sanctions reduced the probability that individuals engaged in heavy drinking, but in the equation for drunk driving, when HEAVY was included as a covariate, the results for the sanctions lost statistical significance, and signs on some coefficients on covariates for sanctions became positive. Taken at face value, this pattern of findings suggests that people are rational and forward-looking in their decision to engage in heavy drinking, but conditional on heavy drinking, the decision to drive is irrational (cell 2, Figure 1).

Arcidiacono et al. (2007) investigated whether structural models of forward-looking behavior explain observed patterns of heavy drinking and smoking of men in late middle age in the Health and Retirement study better than myopic models do. The study did not analyze driving, conditional on heavy drinking. They concluded that forward-looking models explain heavy drinking and smoking behaviors better than myopic models do. There is evidence from two waves of the NESARC that major depression is a factor in alcohol-impaired driving (Pogue et al., 2017).

The Survey of Alcohol and Driving (SAD), a three-wave survey of heavy drinking and drinking and driving was conducted in 2011-2012 in eight US cities in four states in the four US Census Areas. The first wave included questions on demographic characteristics of respondents, income, alcohol consumption patterns, health and health behaviors, planning, cognition, personal attributes, such as questions on impulsivity not in the alcohol domain, self-control and on altruism, and motor vehicle insurance, accident/traffic violation history. The SAD excluded persons who did not drive or abstained from alcohol. 1,634 completed responses to wave 1. The data are available from the ICPSR at the University of Michigan.

Forty-three percent of respondents reported that they had driven at least once after having consumed too much alcohol in the past year. By contrast, only 5.8 percent of respondents who said they drove after drinking too much in the *past year* said that they had been arrested on a DWI charge in the last *three years*, an annual probability of 0.019 (Sloan et al., 2014). Some respondents who said they drunk too much to be driving may have had BAC levels below legal thresholds for a DWI conviction.

Drinker-drivers differed in some ways from non-drinker-drivers but were similar on others. Drinker-drivers did not differ on two of three measures of cognitive ability included in the SAD (Sloan et al., 2014). The SAD allowed for a detailed investigation of subjective beliefs. Subjective assessments of the risks of drinking and driving are important since subjective beliefs about such risks have been shown to influence actual driving behavior (Dionne et al., 2007).

Comparing subjective probabilities to their objective probability counterparts, there was no evidence of optimism bias, i.e., that drinker-drivers engaged in this activity because they underestimated objective probabilities of adverse consequences of this behavior (Sloan et al., 2013a). Compared to others, drinker-drivers were less prone to plan events involving drinking, e.g., selecting a designated driver in advance of drinking. Overall, drinker-drivers were more likely to make impulsive decisions, suggesting these persons were more often swayed by emotions. The questions on impulsivity did not mention alcohol or drunk driving, but other referred to other contexts and decisions. On time preference, analysis of SAD data revealed evidence of hyperbolic discounting by drinker-drivers. More specifically, short-term discount rates were 0.124 higher than long-term rates for persons who reported drinking and driving on five or more occasions than for persons who did not drink and drive at all during the year before the survey (Sloan et al., 2014). In sum, there is empirical support for parts of the behavioral economics critique applied to drinking and driving.

Empirical Evidence on the Effects of Specific Public Policy Options to Reduce Drinking and Driving

Laws and other policies aimed at reducing heavy drinking and driving while intoxicated are of three types. One group primarily is implemented to *deter* these behaviors. Included in this group are excise taxes on alcohol, policing and fines and incarceration in jail following a DWI conviction, and compulsory, experience-rated premiums for third-party motor vehicle insurance. Jail terms for DWI tend to be very short. Thus, the deterrent is mainly the embarrassment and discomfort of being jailed and having to report to an employer that the employee cannot come to work.

A second group aims to reduce the option that individuals have to engage in these behavior, i.e.. to *incapacitate*. This group includes long prison terms, administrative license revocation, minimum drinking age laws strengthened by zero tolerance (BAC=0), SCRAM devices and ignition interlock, and dram shop and social host liability laws which impose tort

liability on alcohol servers for serving minors or obviously intoxicated adults in dram shop and hosts of social events for social host liability. A third approach involves *treatment* for alcohol use disorders which may be subsidized and used on a voluntary basis or compulsory part of sentencing following conviction on a DWI charge.

Criminal sanctions fall into all three categories. Except for third-party liability applicable to motor vehicle accidents, which aims at deterrence as well as risk protection, civil law focuses on the second. Bartenders and social hosts are charged with the responsibility of controlling the behavior of irresponsible drinkers.

Criminal Sanctions

Figure 2 shows the disposition of arrests for a sample of DWI charge by calendar year, 2001-2011, in North Carolina as reported in state court records (Griffin et al., 2014). Only the first arrest in a calendar year was included in the sample. Some arrestees had prior DWI arrests. Data for Figure 2 came from a sample of arrests on a charge of driving while intoxicated. Some arrested had other charges in addition to DWI drawn from electronic court records for 2001-2011 in the state's Automated Criminal Infractions Information System. Where two percentages appear, the first is for the share of all defendants in the data. Otherwise, the percentage is only for the immediately preceding category. (Source: Griffin et al., 2014, p. 1414.)

Of the half a million arrests for DWI, prosecutors pursued 81 percent of the cases, declining to prosecute the remainder. Of these prosecuted, 67 percent resulted in the defendant pleading guilty. Among arrestees, not pleading guilty, 61 percent were convicted. That is (ignoring the "all others" category for which pleading guilty or not could not be determined from the court records), about half of the persons arrested for a DWI were convicted and hence subject to criminal sanctions.

It is apparent that outcomes following arrest differed considerably as measured by the probabilities of being prosecuted, convicted, and assignment of penalties conditional on a conviction. This variation in outcomes greatly complicates an individual's task in computing ex ante costs of drinking and driving, gauged in terms of criminal sanctions, not to mention the other costs. The basic resolution process is common to all US states. Thus, there is no reason to believe that patterns documented for North Carolina are atypical.

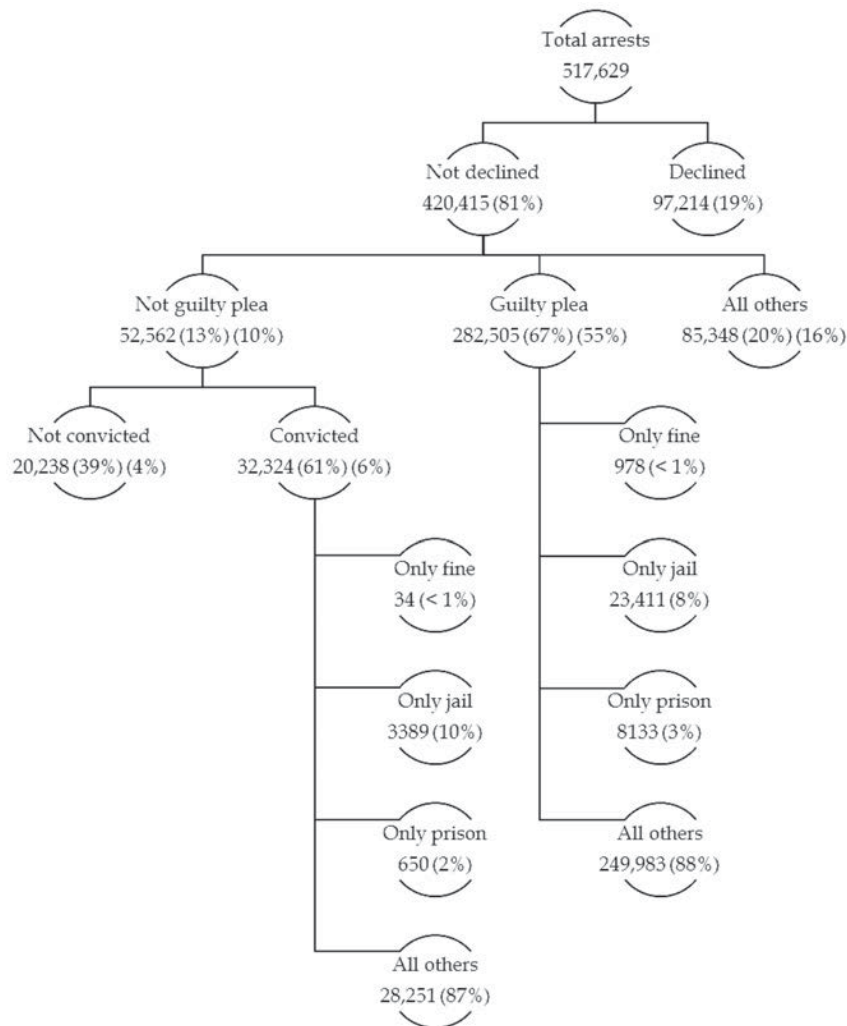


Figure 2. Case Depositions of Persons Arrested for a DWI in North Carolina

Source: Griffin et al. (2014).

With few exceptions, economic studies on the topic of effectiveness of public policies designed to curb rates of drinking and driving, especially those published in the 1990s and early 2000s, focused on criminal laws, but have ignored the complexities seen in Figure 2. Studies of criminal sanctions for DWI have included: laws to permit preliminary breath tests following a stop for suspected DWI; sobriety checkpoints to permit stops by police to screen for driving while intoxicated; administrative license suspension which permits administrative revocation of a driver's license if a test shows a BAC above the legal threshold; anti-pleas bargaining statutes, laws making it more difficult for prosecutors and defense counsel to reduce a DWI charge to a lesser charge; and mandatory minimum terms of incarceration in jail and fines; laws permitting

ignition interlock and /or SCRAM devices for persons convicted on a DWI charge; and open container laws/anti-consumption laws for all motor vehicle occupants.

The underlying assumption was that if a state legislature enacted a new law, the expected cost of drinking and driving would increase, thus curbing such behavior. Assumed implicitly is that non-legislative actors, i.e., law enforcement, judicial system participants, including prosecutors and judges, and probation/parole officers would comply with these statutory changes and not offset the legislative intent, e.g., by being more lenient in granting guilty pleas in which DWI is reduced to a lesser charge. The studies did not assess details of implementation of the laws, only that a state had the law on the books.

In recent years, many states have implemented statewide sentencing guidelines. With sentencing guidelines for a long list of offenses, the laws for DWI represent only a few from a long list of offense types (Kramer and Ulmer, 2009). As already noted, an additional challenge in evaluating the effectiveness of individual laws and is that several laws were often enacted simultaneously.

The most direct assessments of effects of such statutory changes are in studies using self—reported heavy or binge drinking and drinking and driving as dependent variables. Kenkel (1993) found empirical support for the effectiveness of these laws for heavy drinking but not for drinking and driving. Using the same dependent variables but different data and a specification more focused on civil than criminal sanctions, Sloan et al. (1995) found no empirical support for the effectiveness of the criminal sanctions they included—license revocation, and minimum jail terms and fines. Stout et al. (2000) obtained some empirical support for mandatory fines and jail terms. With measures of mortality as the dependent variables, Ruhm (1996) found little support for the effectiveness of the criminal sanctions he studied.

Sloan et al. (2017), with data from the Survey of Alcohol and Driving, used data from an experimental module in which individual's subjective probabilities of sanctions were randomly updated by the interview. More specifically, the survey elicited the subjective probability that the respondent would drink and drive in the next year and subjective probabilities on specific sanctions being applied if the respondent drank and drove. Then the subjective probability of the sanction was increased by a randomly-selected multiplier. The respondent was then asked what the probability of drinking and driving in the next year would be. The authors found that drivers' subjective probabilities about their future alcohol-impaired driving fell in response to randomly-

generated increases in the probability of being stopped by police, but there was little or no decrease in their predictions about future drinking and driving from randomly-generated increases in penalties following a conviction for DWI.

The bottom line is that overall these laws overall appear, at least taken individually, not to be very effective deterrents. Incurring any criminal sanctions appears to be effective, judging from the studies of specific deterrence.

Policing/Other Enforcement., Objective measures of the probability of being stopped and arrested for a DWI by police are unavailable on a multistate basis. Proxies, such as the ratio of police to population have been employed. Sloan et al. (1995) included the police/population ratio as a covariate, finding that this ratio had a statistically significant negative effect on the probability that the survey respondent reported having had a binge episode in the past year, but there was no effect on the fraction of binge drinking episodes which were followed by driving. Sloan et al. (1994) obtained a negative and statistically significant effect of the police/population ratio on traffic fatalities.

Several states have implemented laws allowing for sobriety checkpoints. By increasing the probability of a stop, these laws are designed to reduce drinking and driving. Few empirical studies have examined the effects of sobriety checkpoints empirically. Kenkel (1993) reported a statistically significant negative effect on self-reported drunk driving for males but not for females. Stringer et al. (2019) documented a negative relationship between DWI arrests and fatal alcohol-related crashes. The relationship was non-linear, reflecting diminishing returns to arrests. As in the multistate studies, the study did not account for possible endogeneity of policing. State laws authorizing police to set up sobriety checkpoints to detect drunk driving should increase the probability of arrest for DWI. Kenkel (1993) obtained negative and statistically significant coefficients in his analysis of heavy drinking.

In sum, although understudied, the evidence to date from cross-sectional analysis and from a study that used randomized probabilities of being stopped, suggests that higher levels of policing of drinking driving is an effective policy instrument for reducing drinking and driving.

Administrative per se laws require the state licensing agency to suspend or revoke the driver's license following an arrest for DWI. This makes the probability that a sanction will occur for driving and driving immediate and more certain. Implied consent laws require license suspension of the driver's license if the driver refuses to submit to alcohol testing at the stop.

Having evidence of DWI from an objective test increases the probability of conviction and hence that criminal sanctions will be imposed.

Relatively few studies have included covariates for enactment of these state laws. Ruhm (1993) did not find that either law affected traffic fatalities. Kenkel (1993) found that these policies reduced the probability of heavy drinking but not drunk driving when a covariate for heavy drinking was included as a covariate.

Still another option is to lower the BAC threshold for a DWI charge from 0.08 to 0.05. Several European countries have lowered their illegal BAC levels to 0.05. Albalade (2008) used panel data covering 1991 to 2003 from several European countries with differences-in-differences analysis to assess the effectiveness of this policy change. The dependent variables were the motor vehicle fatality rates per million inhabitants of each age-sex specific population group and such fatalities per 100,000 kilometers driven. While the author generally concluded that lowering the BAC level has been an effective policy in terms of reductions in such fatalities, he also found differences in effectiveness depending on the age, sex, and urban-rural zone group studied. The policy was especially effective for young males in urban areas. Based on his empirical analysis, Grant (2016) advocated for large penalties for drunk driving at high BACs. However, the empirical analysis was described in a very compact form, making the strength of the underlying data and estimation method difficult to assess.

Incapacitation

When deterrence is likely to be ineffective because heavy drinking and/or drunk driving are irrational choices, an option is to incapacitate the driver. This can be accomplished by incarceration. Less extreme policies include ignition interlock and use of SCRAM devices. On the premise that young persons are less experienced and less likely to be rational and forward-looking, states have enacted laws directed at the young driver.

Elder et al. (2011) reviewed 11 studies on the effectiveness of interlock devices, finding that such devices reduced DWI re-arrest rates while they were in use. However, there is no lasting effect. Once removed, re-arrest rates reverted to levels of persons with similar attributes with no interlock. This result implies that interlock devices have no specific deterrent effect. Given the low number of persons who receive interlock devices, the study provided no evidence on effects of interlock devices on motor vehicle crashes. Evaluations of SCRAM devices have

been based on small samples, limiting conclusions that can be made about their effectiveness (see e.g., Marquis and McKnight, 2009, and Caluzzi et al., 2019).

Laws prohibiting sales of alcoholic beverages to “underage” persons are in place in all US states. There is a strong rationale for such restrictions. First, there is biological evidence that alcohol adversely affects brain development of persons during adolescence (e.g., Rice and Barone, 2000). Second, youths are less likely to consider the long-term adverse consequences of drinking in general and drinking and driving in particular. There is some laboratory evidence that youths discount future utility relatively heavily, thus underestimating the future internal cost of their current risky behaviors (O’Donoghue and Rabin, 2011). Bans on youth drinking are combined with zero tolerance laws which define a BAC greater than zero or greater than 0.02 as a DWI. In response to a US statute, all states implemented zero tolerance laws but fortunately for research, at different times. In contrast to the paucity of evidence on effectiveness of ignition interlock and SCRAM devices, there is a large body of evidence on the effectiveness of underage drinking laws and excellent summaries of the empirical evidence (Carpenter, 2009 and Carpenter and Dobkin, 2011). These papers describe much of the prior empirical evidence as well as providing new evidence.

Carpenter (2007), taking advantage of the staggered implementation of state zero tolerance laws, found that such laws reduced arrests for DWI among 18-20 year olds, but had no effect on DWI arrests of 22-24 year olds for whom no effect was intended. But there could have been a rebound effect after the restriction no longer applied. In addition, the laws led to a reduction in arrests for public drunkenness and disorderly conduct, and property crime among 18-20 year olds, but had no statistical effects on these types of crimes for 22-24 year olds.

Carpenter and Dobkin (2011) used a panel design and RDD to assess the effects of minimum drinking age laws. College presidents and other higher education officials had signed a petition calling for reexamination of the minimum drinking age in the US. Drinking on college campuses is a problem which might have been made easier for administrators if the laws were relaxed. Using panel data, the authors found that minimum drinking age laws reduced deaths from motor vehicle deaths, but not all-cause mortality, which includes deaths from internal causes, such as cancer. By contrast, there was generally no effect of such laws on mortality of other age groups. Their RDD analysis showed a sharp increase in motor vehicle mortality at age

21. There was a smaller increase in deaths due to suicides at this age threshold. There was a positive trend in age for deaths to internal causes, but only a slight break (increase) at age 21. The authors emphasized that a full welfare analysis of such laws would consider the benefits as well as the costs of drinking.

Studies by Liang and Huang (2008) and Lovenheim and Slemrod (2010) lend empirical support to Carpenter's and Carpenter and Dobkin's findings. However, contradictory findings are reported by Lindo et al. (2016) with data from New South Wales Australia. The authors speculated that the difference in findings may be due to stricter enforcement of drinking and driving laws in Australia than in the US.

For both license revocation and incarceration, there is the remote possibility (remote given that convictions for DWI generally result in very short incarceration periods, generally no more than a few days) that reduced recidivism rates may reflect incapacitation as well as specific deterrence. Hansen (2016) investigated this issue. In the state of Washington, persons convicted on a DWI charge received short sentences with jail time ranging from 24 hours to at most a few months. Mean jail time was slightly under four days. This is far too little time for incapacitation to keep convicted persons from recidivating. Similarly, license revocation periods were short. Licenses could be reinstated during the suspension period if the person agreed to install ignition interlock in the person's motor vehicles. Of course, some drivers probably drove without a valid license, but there were no data on this, Hansen's approach for disentangling deterrence from incapacitation was to observe whether recidivism fell more or less during the period the person was incapacitated. He found that most of the decline in recidivism occurred after the period during which persons were incapacitated, leading to the conclusion that specific deterrence was more important in reducing the probability of re-arrest for DWI during follow-up, than incapacitation.

Civil Law Sanctions and Motor Vehicle Liability Insurance

Civil sanctions and automobile insurance also have a role in reducing rates of drinking and driving and its consequences. Several types of civil sanctions exist. The main sanctions involve tort liability for causing an accident resulting in injury to property and/or persons. Other civil law sanctions are dram shop and social host liability. The cost of accidents is typically covered by motor vehicle liability insurance. Compensation is often negotiated between liability insurers and plaintiffs resulting in a settlement rather than by court verdict.

Coexisting with applicable criminal law is the drunk driver's liability for property damage and personal injuries resulting from accidents under tort law, which aims to deter careless behavior by making parties (individuals, firms, etc.) financially responsible for the harms their behaviors incur. Unlike some other forms of liability insurance (e.g., medical malpractice insurance), motor vehicle liability insurance premiums are highly experience rated (Sloan and Githens, 1994). Several states specify experience rating formulas. States specify make motor vehicle registration contingent on the owner demonstrating that the owner has a liability insurance policy with liability limits at or above the levels required under state law. Some states require purchase of collision (first-party) insurance (Sloan et al., 1995), but minimum levels are also often required by banks for loans and for leases. A record of having had chargeable motor vehicle accidents previously and/or a previous DWI conviction also affects willingness of standard insurers to insure the individual (insurer underwriting). Persons rejected by standard insurers may seek coverage from nonstandard insurers or from a state's high-risk pool.

Using data from the 1989 BRFSS, Sloan and Githens (1994) regressed three dependent variables, the probability of consuming alcohol at all, the probability of driving after having too much to drink, and the number of drunk driving episodes, all defined for the past month, on the liability insurance premium differentials between standard and nonstandard insurers and between standard and high-risk pool premiums. Nonstandard insurers often insure risks that standard insurers do not insure. Some states have established risk pools to provide liability insurers to motor vehicle owners standard insurers refuse to insure.

Not surprisingly, the premium differentials had no effect on the probability of drinking at all. However, increases in non-standard and risk pool premiums relative to standard insurer premiums reduced the probability of drinking and driving at all and the number of drunk driving episodes in the past month. This tax on drinking and driving is an effective deterrent.

Dram shop liability makes alcohol sellers liable for sales of alcoholic beverages to underage persons and to persons whose alcohol consumption makes them a dangerous operator of a motor vehicle (obviously intoxicated adults). In the event of property damage or personal injury, the injury victim can sue the seller for damages. A survey of bartenders revealed that bartenders are well aware of the probability that they and the bar owner may be sued for serving obviously-intoxicated adults or minors, irrespective of their intoxication status (Sloan et al.,

2000). Other studies found that implementing a state dram shop law, either by legislation or judicial decision, reduces motor vehicle fatalities (Chaloupka et al, 1993, Ruhm, 1993, Whetten-Goldstein et al., 2000). An exception is Sloan et al. (1995), but the dependent variables were drinking, binge drinking, and drinking and driving, not motor vehicle fatalities.

Using data from the BRFSS, Stout et al. (2000) found that imposing tort liability on bars reduced self-reported incidents of drunk driving among all drinkers ($p=0.043$) but did not reduce the probability of heavy episodic drinking or drinking and driving among heavy drinkers. Overall, results on dram shop liability in these studies were more consistently negative and statistically significant than results on criminal sanctions were.

Serving alcohol to minors is illegal in all states. Social host liability aims to add civil penalties to the criminal sanctions. Social host liability involves imposing tort liability on a host of a private party if the party provides alcohol to minors which in turn leads to injury of a third person. Social host liability is designed to increase the price of alcohol consumption by minors in private settings, such as in social events near or at college campuses. However, an adverse effect of social host liability is that it may transfer the venues where alcohol is consumed by minors, such as to minors' own homes but to which driving by minors is necessary or to an automobile where adults are not present. This concern is somewhat mitigated for adults by evidence from a national study of social host liability which reported that such liability reduced the self-reported liability lowered the self-reported probability of having an episode of heavy drinking ($p=0.0004$) and drinking and driving among all drinkers ($p=0.0005$)

In an analysis that focused specifically on effects of social host liability, Dills (2010) found that among 18 to 20 year-olds, social host liability reduced the alcohol-impaired motor vehicle fatality rate by nine percent. Analysis of survey data from the BRFSS indicated that the reduction in such mortality resulted mostly from reduced drinking and driving rather than reductions in alcohol consumption. One can speculate that this is the result of adult's (or sometimes a host who is also a minor) intervention to prevent driving from parties in an intoxicated state. This is an exception to the general finding reported above that criminal sanctions were more likely to reduce heavy or binge drinking rather than driving conditional on having consumed too much alcohol. But the difference is that here it is likely it is the adult host rather than drinker who makes the driving decision.

Taxi, Uber, and Lyft drivers are likely to be understandably reluctant to pick up intoxicated persons from bars or private social events. To this author's knowledge, there is no empirical evidence on the number of drunk drivers transported by commercial drivers. In Korea, a designated driver industry has emerged (Chung et al., 2014). Such drivers presumably are specialized in transporting intoxicated customers and are compensated for the inconveniences such services entail. Entry and exit costs are virtually zero. All the firm has to do is have a list of drivers and a call center. Designated drivers only need a valid driver's license and liability insurance that covers driving other owners' vehicles. To assess the effectiveness of the designated driver program, the authors estimated parameters of an equation with the dependent variable being the log odds ratio of alcohol-involved fatality rates, and alternatively total traffic fatality rates, in region i and year t . The key explanatory variable was the number of designated driving firms per 1,000 population (arguably endogenous, even though endogeneity would presumably drive the parameter estimates of the firm/population ratio to zero). The authors found that the firm/population ratio had statistically significant negative impacts on fatality rates which were largely insensitive to changes in equation specification. A comparison of effects during the day versus at night when designated driver use was much higher lent support to the authors' basic findings.

Price of Alcoholic Beverages

The price of alcoholic beverages is affected by excise taxes on such beverages, beer, wine, and spirits. In the US, there is a federal excise tax. In addition, states impose excise taxes on these beverages. Due in large part to the strength of the alcohol lobby, the real price of alcoholic beverages on the US has decreased in recent years (Xu and Chaloupka, 2011). Excise taxes have been opposed by the alcohol industry, broadly defined. There is evidence of overshifting. That is, when excise taxes increase, prices for alcoholic beverages have increased by more than the amount of excise tax increases (Cook, 1981; Kenkel, 2005; Young and Bielinska-Kwapisz, 2002). Price elasticities of demand are non-trivial and tend to be higher in the long- than in the short-run (Cawley and Ruhm, 2012).

Several excellent literature reviews exist on the topic of the price elasticity of alcohol prices on consumption and on the reduction of adverse effects of alcohol consumption resulting from such taxes (e.g., Chaloupka et al., 2002, 2019; Cook and Moore, 2000; Xu and Chaloupka, 2011). Thus, rather than repeat these reviews here, readers are encouraged to read these reviews.

Overall, increased excise taxes should be an integral part of a package of policies to reduce heavy alcohol use and its adverse consequences, including driving under the influence of alcohol.

Another element of price is the time price of alcohol. This price is influenced by the density of alcohol sellers in a geographic area and hours of service. Picone et al. (2010) used longitudinal data from 1985 to 2001 to empirically assess the impact of distance from place of residence to bars on alcohol consumption in four large US cities from 1985 to 2001. Higher density of bars within 0.5 km of a person's residence was associated with small increases in alcohol consumption. However, including person-specific fixed effects, the relationship between alcohol consumption and the number of bars within a 0.5 km radius of the person's place of residence disappeared. Tests for endogeneity of the number of bars within the immediate vicinity of respondents' homes failed to reject the null hypothesis that the number of bars is exogenous. The authors concluded that bar density in the area surrounding the individuals' homes has at most a very small positive effect on alcohol consumption. A comprehensive review of the literature on the subject, mostly outside of the economic literature, concluded that although associations exist, there is little evidence of a causal effect of distance to alcohol seller (Gmel et al., 2016).

Anderson and colleagues (2016), a study not included in Gmel et al.'s review, analyzed county-level data from Kansas for the years 1977-2011. Even after nationwide prohibition of sales of alcohol was repealed in the US in 1933, Kansas prohibited the sale of on-premises consumption. In 1987, bars and restaurants in 36 counties in Kansas were permitted to sell alcoholic beverages if they received at least 30 percent of their revenue from food sales. Over time, most counties in Kansas permitted sale of alcoholic beverages on this basis, but adoption was staggered. Using date of legalization of by-the-drink sales as an IV for on-premises licenses in the county/year, the authors found that a 10 percent increase in on-premise licenses led to a from three to five percent increase in violent crime. The estimated effect of on-premise licenses on property crime were smaller in magnitude and not statistically significant. These results imply that although bar density has little or no impact on rates of drunk driving, increases in density could have other adverse effects on the neighborhoods in which they are located.

Alcohol Treatment

Problems with alcohol use have many lay terms. In more technical language, many but not all drinker drivers, e.g., many heavy “social” drinkers, have an alcohol use disorder (AUD).

AUD refers to compulsive alcohol use, loss of control over alcohol intake, and a negative emotional state when not consuming alcohol. Some persons with AUD have to drink more to obtain the same effect (tolerance) and experience withdrawal effects when they stop consuming it.

There are many forms of alcohol treatment: outpatient for counseling (cognitive-behavioral therapy, motivational enhancement therapy, marital and family counseling, brief interventions) and medication support (currently there are three approved medications in the US); intensive outpatient and partial hospitalization; residential—24-hour/day programs in a confined setting, such as a hospital; and intensive inpatient care for medically-directed 24-hour care to manage withdrawal.

Many persons undergoing treatment do so voluntarily. Courts do sometimes compel forms of treatment at verdict. Some of these persons receive treatment in specialized drug treatment, DWI, or a combination of drug treatment and DWI courts (termed “hybrid courts”). These are multidisciplinary organizations bringing together court personnel (e.g., prosecutors, judges) as well as treatment professionals. Most often hybrid courts treat persons referred to them for drug treatment (Sloan et al., 2016). In 2018, there were over 1,500 drug treatment courts in the US (Drug Courts, 2018). DWI courts were far less numerous.

A full evaluation of the effectiveness of studies of AUD treatment effectiveness using the four treatment modalities just described is beyond the scope of this review. In a highly cited literature review, Room and Babor (2005) reached four conclusions about the effectiveness of alcohol therapy. (1) Persons receiving treatment in a timely manner generally have better outcomes than comparable persons who do not; (2) intensity and duration of treatment are not associated with much greater improvements in long-term outcomes; (3) medically-based inpatient treatment, although more costly, does not generally yield better outcomes than non-medical or outpatient treatment; and (4) there is little evidence as to which form of therapy yields better outcomes—psychotherapy or pharmacological therapy.

There are non-refereed reports of the effectiveness of DWI courts (e.g., Carey et al., 2008; Carey et al. 2014). One report of DWI courts in Michigan concluded that recidivism rates among former participants in DWI court programs in that state were 19 times *less* likely to be re-arrested for DWI (Carey et al. 2008). In a study using data from North Carolina DWI and hybrid courts, Sloan et al., (2016) found evidence of reductions in recidivism over a four-year follow-up

period among program completers, but the reductions were far lower than those reported by Carey et al. (2008). Unlike Carey et al., Sloan et al. had a matched control group obtained from state court records: persons convicted of a DWI not referred to a specialized treatment court propensity score matched to enrollees in DWI court programs. With a four-year follow-up, persons convicted of a DWI and referred to a specialty court and who completed the program, were less likely to be re-arrested on a DWI charge than were comparable persons convicted of a DWI who were not referred to such programs. There was a high dropout rate. High rates of non-completion are common among specialized treatment court programs (U.S. General Accounting Office, 1997).

Using data from six Michigan courts and one North Carolina court, Sloan et al. (2013b) found that higher service intensity of the court programs led to better outcomes, a result inconsistent with Room and Babor's second conclusion about alcohol treatment in general that greater service intensity does not lead to better outcomes. In a non-DWI court study with Canadian data that used indexes reflective of alcohol problems and future arrests for DWI and RDD (Flam-Zalcman et al., 2013), observed substantial reductions in alcohol use during the six-month follow-up at the point in which the point score led to assignment to 16-hour versus an eight-hour brief treatment intervention. Interpreted as a more intensive treatment than the eight-hour intervention, this study also suggest that intensity of treatment affects outcomes favorably.

MacDonald et al. (2007)'s study of DWI court effectiveness was based on a randomized controlled trial. Persons convicted for a second or third DWI were referred to a DWI court for sentencing. Those who volunteered to participate in an experiment were randomized to participate in a specialty court program or continue with a non-DWI court. Both groups of persons were interviewed during the two-year follow-up. These data were supplemented with information from official records. Outcome measures were self-reported drunk driving completion of treatment, time in jail, alcohol consumption, and stressful life events. Few differences in outcomes were observed.

Thus, in sum, results on the effectiveness of DWI courts to date have been mixed. These results have been based on data on persons convicted on a DWI charge who were referred to such courts. The numbers of such referrals are miniscule relative to the number of persons convicted of a DWI. Although promising in their design, DWI courts could not have had a discernable impact on drunk driving in the US simply because of the paucity of referrals. Most

persons who are convicted on a charge of DWI and incarcerated serve time in local jails rather than in state prisons. Persons spending time in jails receive very little if any treatment. The jail terms for DWI are too short to permit treatment.

Evidence from clinical trials indicates that treatment which involves a combination of medical management, pharmacotherapy, and cognitive-behavioral therapy is effective (see e.g., Anton et al., 2006). However, there is some question whether results from trials generalize to community populations (see e.g., Blanco et al, 2008). Also, few persons who could benefit from treatment actually receive it. Results from a US-wide survey of persons living in the community, among those with 12-month AUD, 4.5 percent received help from 12-step groups, 3.6 percent from health care practitioners, 2.0 percent from outpatient facilities, and 1.8 percent from rehabilitation programs. The authors attributed these low percentages to fears of stigmatization and beliefs that treatment is ineffective rather than to lack of insurance coverage for these services (Grant et al., 2015). More in-depth analysis of barriers to receipt of treatment is warranted.

Conclusions and Implications for Researchers and Public Policymakers

Some issues related to heavy drinking and drunk driving are settled. Further studies should mainly be addressed to prod policymakers to action. It is known that the number of drinking and driving episodes, are numerous, both in the US and other countries, based on self-report which may be biased downwards, far greater than the number of arrests for DWI and the number of alcohol-related crashes and fatalities. There is empirical support for the notion that the decision to drink and drive is a least partially rational, but on the other hand, sufficiently irrational to call for important roles for incapacitation and AUD treatment. Once intoxicated, individuals' decision-making apparatus is impaired. Some may have the foresight to have selected a designated driver in advance or to engage in heavy drinking at home. But otherwise, it is the role of others, including bartenders and social hosts to control drinking and the drinker.

Overall, raising excise taxes and hence the price of alcohol and laws regarding the minimum drinking age in combination with zero tolerance laws or lowering the BAC threshold for DWI, appear to be highly effective. Given political pressures from the alcohol lobby, excise taxes and the price of alcoholic beverages have declined in real terms. Social host laws have been opposed by other stakeholders, such as college and university administrators. Even though there is less empirical evidence on effectiveness of social host laws, given that much heavy

drinking is at social events attended by youths, these laws can buttress bans on youth purchases of alcohol.

At the next level in effectiveness are dram shop laws and law enforcement. Increases in criminal sanctions following DWI conviction, at least taken individually appear to be the least effective option. Alcohol treatment can be effective, but the major problem is that relative few persons with AUD are treated. The proportion of DWI convictions involving a referral to a specialty court for treating AUD is miniscule.

While under pressure to do something about heavy alcohol consumption and drinking and driving, US and state legislators have supported increased criminal sanctions, such as higher minimum fines and incarceration lengths for convictions on a DWI charge. Given the very low probability of being sentenced following a drinking driving event, the increases that have been enacted could not have been ineffective in general deterrence. Studies that have evaluated these policy changes have yielded mixed results. By contrast, alcohol servers routinely encounter patrons who become intoxicated or want to become intoxicated. Alcohol servers are well-positioned to control heavy drinking and prevent drunk driving by for example arranging for a designated driver. Admittedly, control of patrons may lead to loss of income from tips.

Higher experience-rated compulsory liability insurance premiums for DWI convictions or for at-fault accidents remain in effect for years and are likely to far exceed the cost of fines and short jail terms. Other public policies, not specifically implementing to reduce the social cost of excessive drinking and driving and driving, may be effective in reducing such cost, e.g., provision of public transportation (Jackson and Owens, 2011), but there are too many such policies to them justice in this review.

There are several messages for researchers. Further research on some topics is unlikely to be productive. This includes additional time series-cross section analysis of the effects of state-level legislation, refinements of existing estimates of the own-price elasticity of alcohol, or additional studies of the rational addiction model. Longitudinal microanalysis based on court, corrections, and police data (e.g., stops) are likely to be much more illuminating. Further microanalysis of decision-making using insights of behavioral economics is likely to be worthwhile. There is a large body of research on alcohol treatment but most of this research has had a biological focus. We need a better understanding of barriers to receipt to treatment, including the link between judicial decisions and receipt of treatment.

With regard to methodologies, the randomized controlled trial (RCT) is the gold standard. Although used to study the effectiveness of alcohol treatment, there are virtually no RCTs of policy options for reducing rates of drunk driving. Admittedly, there are impediments to such research. Aside from its high cost, it is unethical to apply different criminal sanctions to a treatment and control group for example. However, since participation in a specialty court program is not standard of care, it should be possible to randomize in this context.

When conducting an RCT is not feasible, regression discontinuity design may be an attractive alternative. Instrumental variables have not been used as frequently in studies of heavy drinking and drunk driving because (1) it is often difficult to find valid instruments, and (2) many policies have been assessed in a single study.

This review has focused on economic studies of heavy drinking and drinking and driving. The literature from other disciplines is far larger. Thus, summarizing the entire literature on these topics is not feasible. A search of the Web of Science using the key words “heavy drinking and alcohol” yielded nearly 10,000 cites. A search of “drinking and driving” resulted in about 4,200 citations; only 3.1 percent were in economics journals (accessed 1/10/20). This comparison is not exact since this chapter drew literature primarily by economists but not all of which was published in economics journals. The topic of this chapter is inherently interdisciplinary. Progress will require cooperation among the relevant disciplines as has existed in the past.

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