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SUBJECTIVE BELIEFS, DETERRENCE, AND THE PROPENSITY TO DRIVE WHILE INTOXICATED

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ABSTRACT

This study investigates causal effects of changes in subjective probabilities of being pulled over and involved in accidents if driving while intoxicated on individuals' drinking and driving choices. We also examine how hypothetical changes in perceptions of sanction severity affect drunk driving by experiments randomizing the harshness of punishments. We find that higher perceived risks of being pulled over and involved in accidents deter drinking and driving. However, deterrence is limited to persons who are alcohol addicted, lack of self-control over drinking, and are more impulsive. No deterrent effect of harsher legal punishments is found on individuals' drunk driving choices.

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Introduction

Driving while intoxicated (DWI) is a serious problem in the United States. DWI caused more than 10,000 deaths in 2010 (U.S. National Center for Statistics and Analysis, 2012). Studies have documented that two percent of weekend nighttime drivers on U.S. roads had illegal blood alcohol concentrations (BACs; Lacey et al., 2009), and more than 110 million instances of alcohol-impaired driving occur in U.S. annually (Bergen et al., 2011). Legally intoxicated drivers are 13 times more likely to cause fatal crashes than sober drivers are (Levitt and Porter, 2001).

A growing academic literature has analyzed individuals' risk-taking behaviors using subjective expectations of adverse consequences. Some contend that risk perceptions are even better predictors of individuals' behaviors than the actual outcomes (e.g., Delavande, 2008; Wang, 2014), and public policies designed to reduce undesirable behaviors will not be effective unless they can influence risk perceptions (e.g., Nagin, 1998; Lochner, 2007).

The association between risk perceptions and behaviors has been well documented in a number of contexts other than drinking and driving. Lochner (2007) found that a higher perceived risks of arrest lowered criminal participation in theft. Using a random utility model, Delavande (2008) concluded that subjective probabilities of outcomes of different contraceptive methods, e.g., getting pregnant or contracting a sexually transmitted disease, have more power than objective probabilities based on population actual outcomes in predicting individuals' contraceptive choices. Evidence from bar owners/managers indicated that these persons with higher perceived risks of being cited or sued if serving obviously intoxicated adults or minors were more likely to take precautionary measures to avoid services to intoxicated and underage patrons (Sloan et al., 2000).

In the context of smoking, Wang (2014) showed that subjective probabilities of survival probability explain individuals' smoking decisions, and even exhibit more predictive power than corresponding objective probabilities. Other studies have concluded that persons with lower perceived risks of cigarettes' harmful health consequences were more likely to smoke (e.g., Viscusi, 1990; Viscusi, 1991; Carbone, 2005), even though the subjective probabilities were overestimated.

However, there are few truly comparable studies relating individuals' risk perceptions to decisions in situations where individuals' decision making capacities are likely to be impaired, such as the choice to drive after having had too much to drink. Dionne et al. (2007) studied impacts of the subjective probability of being arrested or involved in an accident when driving while intoxicated on individuals' drinking and driving behavior, finding sizable deterrence from a higher perceived risk. However, the behavior was inferred from individuals' traffic violation records or involvement in accidents, both of which are subject to measurement errors since adverse outcomes only result from a small minority of actual drinking and driving episodes.[3] Other studies lack generalizability in relying on specific populations such as college students or trauma patients (Yao et al., 2013; Ryb et al., 2006).

This study consists of two parts. In the first part, we investigate causal effects of changes in subjective probabilities of being pulled over and having accidents when driving under the influence of alcohol on self-reported drinking and driving behaviors. In the second part, we examine how hypothetical changes in perceptions of penalty severity following a conviction of DWI affect the probability of driving after having had too much drink by experiments randomizing the harshness of punishments.

We improve upon past research linking risk perceptions to drunk driving in several ways. First, we use an instrumental variable (IV) approach to deal with the potential endogeneity of risk perceptions. Individuals' risk perceptions are instrumented by their subjective probabilities of the same adverse consequences for themselves and other persons reported in a follow-up interview.[4] We use different strategies to test the validity of our instruments. Second, rather than focus on a specific population such as college students or trauma patients as earlier studies (e.g., Yao et al., 2013; Ryb et al., 2006), our sample comes from a more general adult driver population in eight cities of varying population sizes and geographically distributed throughout the U.S.. Third, our analysis allows for irrational as well as rational decision making about drinking and driving. While in a standard economic model would have the individual weighing benefits and costs of drinking and driving brought to present value, our data include measures used in the behavioral economics literature. Fourth, we stratify the sample according to personal

[3] Arrests for DWI and accident involvement have been estimated to occur in a small proportion of actual drinking and driving episodes (e.g., Schwartz and Rookey, 2008).
[4] Using lead value as instruments for endogenous variables has been used in a few other studies, e.g., Dahl and DellaVigna (2009).

attributes that are associated with heavy drinking and drunk driving. We find that drinking and driving behavior is only sensitive to risk perceptions of being pulled over and involved in accidents among persons who are addicted to alcohol, lack self-control over drinking, and are more impulsive, while drinking and driving behavior of persons who do not exhibit these attributes is not affected by changes in risk perceptions. We examine channels through which this pattern arises.

Fifth, our data allow an assessment of effects of sanction severity of various types of penalties for a DWI conviction on individuals' drinking and driving choices. Despite widespread interest among public officials in escalating punitive threats to reduce driving under the influence of alcohol, our empirical evidence documents no deterrent effect of sanction severity for DWI in terms of amount of fine, and length of jail sentence, driver license suspension, use of Secure Continuous Remote Alcohol Monitoring (SCRAM) device, and mandatory alcohol counseling. Some earlier studies (e.g., Benson et al., 1999; Sen, 2001; Levitt and Porter, 2001) used objective changes in severity of legal consequences for DWI, i.e., actual changes in law enforcement and statutory changes in laws, and found no deterrence of punishment severity on drinking and driving. However, it is difficult to know whether the non-significant deterrent effects reported in these studies reflect the fact that drunk drivers are undeterred by harsher penalties either because the perceived chance of receiving punishments is low or the respondents are irrational, or just because actual punishment changes have not been translated into subjective beliefs, the argument being that policies designed to curtail crime are effective only if they can actually influence beliefs (Nagin, 1998). We infer that lack of deterrence is most likely to reflect a low probability of actually receiving these penalties.

This paper proceeds as follows. Section I describes the data. Section II presents the estimation method. Results are presented and discussed in in Section IV. Section V concludes the paper.

I. Data

Our survey, the Survey of Alcohol and Driving (SAD), is a longitudinal survey providing detailed information on individuals' risk perception of drinking and driving and individuals' attributes such as self-control, impulsivity, cognition, risk tolerance, time preference, involvement in risky behaviors and socio-demographic characteristics. The survey was conducted by Battelle Memorial Institute in eight geographically dispersed U.S. cities across four states during 2010-2012. The eight cities were: Raleigh, North Carolina (NC); Hickory, NC; Seattle, Washington (WA); Yakima, WA; Philadelphia, Pennsylvania (PA); Wilkes-Barre, PA; Milwaukee, Wisconsin (WI); and La Crosse, WI. The states and cities were selected to yield a broad geographic spread and variety of drinking and driving prevalence, DWI prevention laws and demographic composition.

The baseline interview was conducted in late 2010-early 2011 using Computer Assisted Telephone Interview (CATI), resulting in a sample of 1,634. The follow-up interviews consisted of two waves of web-based surveys conducted by Computer Assisted Self-Administered Interview (CASI). The first wave (CASI-I) was administered one to two months after CATI, consisting of a sample of 1,359 respondents. The second wave (CASI-II) was administered a year after the CASI-I survey, with a sample of 1,187. The loss of sample is due to attrition.

Eligible respondents were persons who had driven a car and consumed alcohol in the past month before the screener interview, were aged 18+, and lived within the geographic boundaries of one of the eight surveyed cities. The surveys oversampled persons who consumed large amounts of alcohol and were prone to DWI to study decision-making behaviors of such individuals in detail.

We limit our sample to respondents with a positive self-reported probability of drinking and driving next year in CASI-I (N=694) in this study. The rationale for this is that when the probability of drinking and driving in the next year was stated by respondents to be zero given existing penalties, the subjective probability of drinking and driving in response to harsher punishments in the randomized experiments would also logically be zero, leading to underestimated deterrent effects of sanction severity. Furthermore, it is the risk perceptions and behaviors of these potential criminals that are more relevant to policies designed to decrease drinking and driving and its associated harms, while respondents who think they have zero probability of drinking and driving in the near future are less likely to actually drink and drive (Sloan et al., 2013).

Dependent Variables

The first part of our analysis focuses on the deterrent effects of risk perceptions, i.e., subjective probabilities of being pulled over by a police officer and increases in the chance of being involved in a motor vehicle accident when driving while intoxicated compared to driving when sober, on the number of times the person actually drinking and driving in the year after the risk perceptions were elicited. Response categories to drinking and driving frequency in the year are 0, 1, 2, 3-4, and >4 times. We code 3-4 as 3.5 and >4 as 7. The results are insensitive to the precise algorithm for recoding the open-ended category.

The second part analyzes deterrent effects of sanction severity on subjective probabilities of drinking and driving. The CASI-I and CASI-II survey respondents were asked the percent chance that they would drink and drive at least once during the following year, first in the "low experiment," if the legal penalties, e.g., length of jail sentence, were (1+(X+2)*0.1) times of his or her baseline beliefs, where X was randomly selected in increments of 1 from interval of 1 to 7, then in the "high experiment" where punishments were harsher, e.g., (1+(X+2)*0.3) times the baseline beliefs. Such probabilistic questions are a standard elicitation method (Manski, 2004) and are now used in a number of large household surveys such as Health and Retirement Study (Hurd, 2009). Probabilistic expectations have been shown to be good predictors of actual behaviors in situations in which individuals have considerable private information (Hurd, 2009). For example, Finkelstein and McGarry (2006) found that the individual's subjective probability of nursing home entry is a good predictor of actual entry. Insler (2014) reported that workers' self-reported probability of working past ages 62 and 65 predict actual retirement well.

One potential deficiency of subjective probability questions (including the above questions on drinking and driving probabilities in the next year given different sanction severities and the questions about risks of being pulled over) is a possibly high frequency of focal responses, e.g., responses of 0, 50 and 100 percent. However, in our survey, for the perceived risks of being pulled over after having had too much to drink, fewer than 15 percent respondents provided these focal values; rather interviewed individuals used the entire range of probabilities from 0 to 100 percent, although the probabilities were frequently rounded to the nearest 5 percent. A high frequency of focal responses is more of a problem in responses to questions regarding subjective probabilities of drinking and driving in the next year under different hypothetical sanction severities: 20 to 40 percent of respondents gave a response of 0 percent to most questions, although fewer than five percent gave responses of 50 and 100 percent. Therefore, in addition to treating subjective probabilities of drinking and driving in the next year as a continuous variable in the regression, we also categorize them into groups (see details in Section II.B). The findings are robust to this alternative specification.

Explanatory Variables

To elicit the individual's subjective beliefs of being pulled over after having had too much drink, the CASI-I and CASI-II surveys asked respondents who reported a positive probability of drinking and driving next year: "On a given occasion, when you drive after you have had too much drink, what is the percent chance you will be pulled over?" For the risk perceptions of being pulled over for the other persons, the surveys asked "On an average weekend evening, what percent of drivers on the road who have had too much to drink will be pulled over."

For the perception of increases in accident risk when driving intoxicated compared to driving sober, the surveys asked: "If you drank 4 drinks and then go home, what would be the odds (compared with not having had any alcohol at all) of getting into accident" with responses choices being: no increase in odds, odds increase 25% or less, odds increase 26-50%, odds increase 51-100%, and odds increase more than 100%. We used values of 0%, 12.5%, 38%, 75.5%, and 150%, respectively, for each of these response categories.

We measured addiction to alcohol by the CAGE. The CAGE was based on affirmative responses to these questions: "Did you more than once want to stop or cut down on your drinking?" "Have people annoyed you by criticizing your drinking?" "Have you ever felt bad or guilty about your drinking?" "Have you ever had a drink first thing in the morning to steady your nerves or get rod or hangover (eye-opener)?" We specify binary variables for 0, 1, 2, and 3-4 affirmative responses to the CAGE questions. We also include binary variables for whether or not the individual reported ever using licit psychotropic drugs without a prescription or illicit drugs, currently smoked, and a measure of risk-taking in the driving domain-- being willing to speed 15 mph over the speed limit in order to not be late for an important meeting with a 10 percent chance of being caught by the police.

The SAD also included a question about the difficulty the individual experienced in controlling his or her drinking. The question was: "If you have to drive home from some place where drinks are being served, do you find it very easy, somewhat easy, somewhat difficult, or very difficult to limit your drinking?" We specify a binary variable for "somewhat difficult" and "very difficult" to control drinking as lack of self-control with the omitted reference group being "very easy" and "somewhat easy."

Critics of neoclassical economic decision-making have suggested that rather than involve a cold cost versus benefit calculation, many decisions are made in an emotionally changed context. There are likely to be substantial interpersonal differences in the role of emotions in decision making. Therefore, we include a covariate for impulsivity. We measure impulsivity from responses to 12 statements on a five-point scale ranging from "strongly agree" to "strongly disagree". The 12 statements are: "I rarely make hasty decisions;" "I never seem to be able to get organized;" "I fly off the handle;" "There are so many little jobs that need to be done that I sometimes just ignore them all;" "I control my temper;" "I do things on impulse that I later regret;" "I often worry about things that might go wrong;" "I always consider the consequences before I take action;" "I am not a worrier;" "I plan for the future;" "I often do things on the spur of the moment;" "I finish what I start;" and "I act on impulse."[5] The impulsivity index scale varies from 12 to 60, with higher values indicating greater impulsivity.

Cognitive ability has been shown to affect decision making in a variety of contexts, ranging from decisions about portfolio choice (Christelis et al., 2010) to purchases of health insurance (Fang et al., 2008). The cognition measure used in this study was measured by the Telephone Interview for Cognitive Status (TICS), a brief standardized test of cognitive ability and used in Health and Retirement Study (HRS), including questions on object naming and current affair information. The TICS-based cognition scale ranges from 0 to 13, with higher values indicating better cognitive functioning.

Our measure of risk tolerance also comes from the HRS. A respondent's risk tolerance is measured by responses to questions posing a series of hypothetical gambles over lifetime income. The SAD elicited respondents' willingness to accept an equally good job as the current one, but with equal chance, the new job would double income or cut income by a specific fraction[6]. The questions separated the respondents into four ordered risk tolerance categories. Barsky et al.

[5] We thank George Loewenstein for providing this set of questions to us. The properties of this impulsivity scale can be found at Loewenstein et al. (2001).

[6] Although risk tolerance elicited from hypothetical gambles is subject to measurement error, a number of studies have shown it to be a good predictor of actual risk-taking behaviors, for example, Barsky (1997) on smoking, drinking and insurance purchase; Fang et al. (2008) on Medigap insurance purchase; Kimball et al. (2008) on household asset allocation decisions, and Schmidt (2008) on the timing of marriage and childbearing.

(1997) constructed cardinal proxy values for each of these categories (see their Table I). Based on their study, we used proxy values of 0.15, 0.28, 0.35 and 0.57 for each of the risk tolerance category with higher values indicating more risk tolerant.

We use financial planning horizon to proxy individuals' time preference. The SAD asked, "In planning your savings and spending, which of the following time periods is most important to you and your household?" with responses choices: few months; year; few years; 5-10 years; and longer than 10 years. We use values of 0.5, 1, 2.5, 7.5, and 10 for each of these response categories to measure the financial planning horizon in years. The explanatory variables also include demographic characteristics for age, gender, race, marital status, educational years and household income.

II. Empirical Specification

A. Deterrent Effects of Perceptions of Pull Over and Accidents Risks

1. Baseline Model

We begin by estimating the following ordinary least squares (OLS) specification:

$$DD_i = \beta_0 + \beta_1 PullOver\_Prob_i + \beta_2 Accident\_Prob_i + \beta_3 X_i + u_i \qquad (1)$$

where i indexes individuals, DD is the number of drinking and driving episodes in the year between the CASI-I and CASI-II surveys; $PullOver\_Prob$ and $Accident\_Prob$ represent subjective probabilities of being pulled over and perceived increases in risk of being involved in a motor vehicle accident for respondents themselves when drinking and driving, respectively, reported in the CASI-I survey. X is a set of controls--age, gender, race, marital status, years of education and household income.

Ordinary least squares may yield biased estimates of effects of subjective beliefs about adverse consequences of drinking and driving if subjective beliefs about being pulled over and increases in the accident probability are associated with unobserved preferences for drinking and driving. For example, hidden risk preferences tied to drinking and driving decisions may at the same time affect risk perceptions. The error term u_i can be decomposed into two components.

$$u_i = \delta_i + \varepsilon_i \qquad (2)$$

where δ_i is unobserved individual heterogeneity, with $cov(PullOver\_Prob_i, \delta_i) \neq 0$ and $cov(Accident\_Prob_i, \delta_i) \neq 0$. ε_i is the random error term and uncorrelated with both $PullOver\_Prob_i$ and $Accident\_Prob_i$. Then equation (1) can be written as

$$DD_i = \beta_0 + \beta_1 PullOver\_Prob_i + \beta_2 Accident\_Prob_i + \beta_3 X_i + \delta_i + \varepsilon_i \qquad (3)$$

2. Instrumental Variable Approach and Instruments' Validity

To deal with potential endogeneity of risk perceptions, we use an IV approach. The IVs are individuals' risk perceptions of being pulled over and of increases in probabilities of being involved in an accident when driving while intoxicated based on questions phrased in the second person and in the third person elicited in the CASI-II survey.

Two conditions must be satisfied for our instruments to be valid. First, the instruments must be correlated with the endogenous variables. Although Bayesian updating makes individuals incrementally adjust their perceived risks based on new information from personal experience,[7] individuals also base subjective probabilities on their prior beliefs (e.g., Lochner, 2007; Nagin, 2013, in the context of crime). This suggests an association between risk perceptions reported in the CASI-I and CASI-II surveys. Appendix Table 1 shows that the IVs are highly correlated with the subjective beliefs from CASI-I, with parameter estimates on CASI-I subjective probabilities ranging from 0.4 to 0.6 with statistical significance at the one percent level. Tests for weak instruments show our IVs are sufficiently strong using the rule of thumb for the first-stage F-statistic of excluded instruments suggested by Staiger and Stock (1997), both when errors are assumed to be independently and identically distributed (i.i.d., Cragg-Donald Wald F-statistics, Cragg and Donald, 1993) and when the i.i.d. assumption is dropped (Kleibergen-Paap rk F-statistic, Kleibergen and Paap, 2006).

The second condition pertains to the overidentifying restriction, i.e., the IVs should be uncorrelated with the unobserved determinants of drinking and driving choices. Although risk perceptions reported in CASI-II survey should not have a direct effect on individuals' drinking and driving decisions in the past, there may be an indirect association between these two sets of variables due to unobserved time-invariant preferences for risky behaviors.

[7] For example, individuals would lower their perceived risks if themselves or others known to them successfully avoid being pulled over or having an accident when driving under the influence of alcohol, while increase their subjective risks if fail to avoid such adverse outcomes.

There are several options for evaluating this possibility; but no single option would be fully convincing on its own. Therefore, we employ three different options. First, we control for a set of proxies for a latent preference for risky behaviors--risk tolerance, time preference, alcohol addiction level, impulsivity, cognitive ability and risky behaviors that may directly capture unobserved preferences for risks, including smoking cigarettes, using hard drugs, and willingness to speed to avoid being late for an appointment--to remove the potential correlation between the instruments and the error term of the drinking and driving equation.

Second, since we have more instruments than endogenous covariates, we test the overidentifying restriction with the Sargan-Hansen test. In Table 2 we show that we cannot reject the null hypothesis that the IVs are uncorrelated with unobserved determinants of drinking and driving.

Third, we regress the number of drinking and driving episodes during the year between the CASI-I and CASI-II surveys on the predicted residuals from the first-stage regressions and find no significant associations (Appendix Table 2). Taken as a whole these results support an inference that our IVs are valid.

Lead or lag values of the endogenous variables have been used as IVs in previous studies. For example, Dahl and DellaVigna (2009) instrumented for movie attendance using the following weekend's attendance to investigate whether violence in movies increases violent crime. Ham et al. (2013) concluded that the lagged value of eating disorder-bulimia nervosa (ED-BN) index is a valid instrument for the current value of ED-BN.

B. Deterrent Effects of Sanction Severity on Drinking and Driving

The second part of our empirical analysis examines the deterrent effects of sanction severity on drinking and driving choices, using experiments conducted in both the CASI-I and CASI-II surveys, which elicited individuals' subjective probability of driving at least once next year after having had too much drink under situations with different randomized penalty severities. There is a concern that respondents may mechanically give a lower probability of drinking and driving when a question on the subjective probability of drinking and driving with higher sanction severity is asked immediately after the same question but with a lower penalty severity. To avoid such bias, we select responses from the same individual from the CASI-I survey for the low experiment and CASI-II survey for the high experiment, and, alternatively, from the CASI-I high experiment and CASI-II low experiment, and examine how the difference in sanction severity between low and high experiment explains differences in the individual's subjective probability of drinking and driving at least once in the following year. The premise underlying this approach is that respondents are unlikely to remember their reported subjective probabilities over a one-year period. The empirical specification is:

$$DD_{j,high,i} - DD_{k,low,i} = \beta_0 + \beta_1(Penalty_{j,high,i} - Penalty_{k,low,i}) + \beta_2 X_i + I_i + \epsilon_i \quad (4)$$

where *DD* is the probability of drinking and driving at least once in the following year, I is a individual respondent fixed effect. j=I or II, k=II or I, representing the CASI-I (I) or CASI-II survey (II). The dependent variable is the difference in the subjective probabilities of drinking and driving at least once in the following year in response to the high experiment and to the low experiment. The key independent variable, $(Penalty_{2,high,i} - Penalty_{1,low,i})$, is the difference in the multipliers of sanction severity in the high and low experiments, for example, $(1+(X_{high}+2)*0.3)-(1+(X_{low}+2)*0.1)$. This difference excludes subjective probabilities of specific adverse consequences that may be endogenous to drinking and driving decisions. Yet one concern on this approach is that individuals' baseline beliefs of penalty severity may differ across waves, for example, due to Bayesian updating. However, our data suggest limited source of Bayesian updating in sanction severity: only 9 of the 1,187 respondents in CASI-II reported they had been arrested for DWI in the year between CASI-I and CASI-II. Moreover, as shown in Appendix Table 3, no significant difference in the baseline beliefs of punishment harshness is detected between the CASI-I and CASI-II surveys, although we do find significant differences across surveys in perceived risks of being pulled over and involved in motor accidents if driving while intoxicated.

To address any remaining concerns about focal responses[8] and also as robustness check, in an additional specification, we categorize the difference in chance of drinking and driving between the high and low experiments, i.e., $(DWI_{j,high,i} - DWI_{k,low,i})$, into five groups: -100 to -50; -49 to -1; 0, 1 to 49, and 50-100 percent. We use the proxy values of -2, -1, 0, 1, and 2, respectively, for each of the categories.

III. Results

[8] 20 to 40 percent of respondents provide the answer of 0 percent in response to subjective probabilities of driving at least once after having had too much drink next year in most hypothetical scenarios with different punishment severity, about 30 percent of persons did not change their subjective probabilities from the low to high experiment.

A. Descriptive Statistics

Descriptive statistics are presented in Table 1. Columns 1 and 2 show mean values for respondents who reported a positive probability of having at least one drinking and driving episode in the next year in the CASI-I survey, i.e., the “restricted sample.” Among these persons, the mean number of self-reported drinking and driving episodes in the year between CASI-I and CASI-II survey is 1.9. The mean subjective probability of being pulled over if driving after having had too much drink is 17.0 percent, over twice the fraction of respondents *actually* pulled over by police while driving for any reason. Compared to driving while sober, “driving after having had too much drink” is believed to increase the motor vehicle accident probability by 43.5 percent on average. The CASI-II survey’s mean subjective probability of being pulled over and the increase in accident risk when drinking and driving are 18.9 and 41.3 percent, respectively. The mean subjective probability of being pulled over on other persons is 10.1 percent.

Within the restricted sample, mean age is 41.7 years; slightly fewer than half of the respondents are female (46.3%). 44.0 percent of respondents are currently married. Mean household income is $79,392. Mean educational attainment is 15.7 years. Nearly a third of persons in the restricted sample (31.1%) answered none of the CAGE questions affirmatively. 17.0 percent of the restricted sample reported ever having used hard drugs, 16.3 percent being cigarette smokers, 27.4 percent willing to speed 15 mph over the speed limit in order to not be late for an important meeting with a 0.10 probability of being caught by the police. The vast majority (86.4%) of respondents reported it was very easy or somewhat easy to limit drinking if they have to drive home from some place where drinks are being served. 54.4 percent of respondents have a risk tolerance value of 0.28, which we classify as “medium risk tolerance.” Such respondents have a mean financial planning horizon of 4.1 years. The mean impulsivity index is 30.5, about in the middle of the possible values, 12-60. The respondents have mean cognition index of 12.1, close to the highest possible value, 13.

Comparing persons in the restricted sample with other respondents, persons in the restricted sample tend to be younger, more likely to be male, hard drug users and willing to speed 15 miles per hour over the speed limit, less likely to be black and married, more impulsive, risk tolerant, and alcohol-addicted, have more difficulty in exercising self-control in their drinking, and have higher cognitive ability on average.

B. Deterrent Effects of Perceptions of Pull Over and Accidents Risks

Table 2 shows the deterrent effects of risk perceptions of being pulled over and increases in accident risks on the number of drinking and driving episodes in one year. Results in the first three columns are based on OLS, and those in the last column on IVs.

The regression in column (4) has a lower number of observations than the regression in column (1) for two reasons. First, the sample size declines due to missing values when we add more covariates. Second, as we use subjective beliefs of being pulled over and accident risks from the CASI-II survey as IVs for individuals' corresponding beliefs in the CASI-I survey, we lose observations due to sample attrition. In order to avoid the possibility that our results are driven by the changing samples, we also run all our OLS regressions on the final sample (N=559)--columns (2) and (3); the latter results are similar to those in column (1).

Both IV and OLS results indicate that having higher subjective probabilities of being pulled over and increases in probabilities of being involved in an accident after having had too much to drink decrease the number of drinking and driving episodes. The IV estimates are more negative than the corresponding OLS estimates, a result not new in studies using IVs (see e.g., Bedard and Dhuey, 2006; Dahl and DellaVigna, 2009; Moretti and Neidell, 2011). Possible reasons for the lower OLS estimates (in absolute value) include: (a) risk perceptions are measured with error; and (b) drinking and driving frequency is positively associated with some unobserved individual attributes, which are also positively associated with perceived risks.

The IV parameter estimates imply that on average, a one percent increase in the subjective probability of being pulled over leads to a 0.016 reduction in number of drinking and driving episodes in one year. A one percentage point perceived increase in the odds of having an accident when driving intoxicated compared with sober decreases the number of drunk driving episodes in one year by 0.010. The F-statistics and Hansen J-statistic suggest our instruments are not weak and satisfy the overidentifying restriction.

Persons who are more addicted to alcohol, smokers, and hard drug users, and who lack self-control in drinking are more likely to engage in drinking and driving. By contrast, females involve less often in drinking and driving. Risk tolerance, impulsivity, and cognition have no impact on the number of drinking and driving episodes.

Because of the stigma attached to driving under the influence of alcohol, one might expect the number of drinking and driving episodes to be underreported. However, although we cannot exclude this possibility, such under-reporting tendency appears to be limited: respondents admit to having engaged in a high number of drinking and driving episodes, at an average of one per person in the year between the CASI-I and CASI-II surveys, although only nine persons were arrested for DWI during the same year.

Since the restricted sample is limited to persons reporting a positive probability of at least one drinking and driving episode next year, we use a Heckman correction procedure to account for selection into the restricted sample (Appendix Table 4). The results are quite similar to those reported in Table 2.

Table 3 shows that only persons who are alcohol-addicted, lack self-control over drinking, and are more impulsive[9] reduce their number of drinking and driving episodes when perceived risks of being pulled over and having accidents increase. By contrast, non-alcohol addicted, well self-controlled, and less impulsive persons are not responsive to changes in these subjective beliefs. An explanation for this pattern relates to differences in costs of being pulled over and having an accident across groups. As shown in Table 4, persons who are alcohol addicted and lack of self-control over alcohol consumption report higher subjective probabilities of being convicted for DWI conditional on being pulled over. Moreover, alcohol-addicted and more impulsive persons are substantially more likely to report that being arrested for DWI would almost ruin their lives than their non-addicted and less impulsive counterparts. A plausible conjecture is that given past encounters with the law, these persons are more sensitive to an additional arrest for DWI, as criminal penalty severity tends to increase with past criminal records, for example, punishments for DWI recidivism are harsher than first offenses. However, few differences are detected for the perceived severity of legal punishments across these groups, in terms of amount of fine, length of jail sentence, driver license suspension, SCRAM use, and mandatory alcohol counseling.

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[9] A respondent is grouped as more impulsive if his/her impulsivity index value is between 30-60, while less impulsive if the impulsivity index value ranges from 12 to 30. .

The non-significant differences in sanction severity among groups are consistent with estimates in Table 5, which show no deterrent effect of harsher perceived punishments in the form of amount of fine, and length of jail, license suspension, SCRAM use and alcohol counseling time on drinking and driving probabilities.

C. Deterrent Effects of Increased Sanction Severity

In the second part of our empirical analysis, we investigate how sanction severity for DWI affects subjective probabilities of drinking and driving at least once during the following year. In Panel A of Table 5, there are no deterrent effects of the severity of sanctions in terms of amount of fine, and length of sentence, license suspension, SCRAM use and mandatory alcohol counseling. Panel B categorizes the differences in DWI probability into five groups to deal with high frequency of focal point responses. Results are similar to estimates in Panel A.

Non-response to harsher sanction severity may reflect that the severity are not sufficiently high,[10] but more likely in our survey, the probability of being detected or punished for DWI is small enough such that the sanction threats generate no marginal effect on deterrence. According the data from the SAD, the objective probability of a DWI conviction conditional on a drinking and driving is only 0.006. Probabilities of receiving fine, jail time, license suspension, SCRAM, and alcohol counseling given a DWI conviction were perceived to be, respectively, 0.88, 0.29, 0.71, 0.34, and 0.76. In general, an arrest on a charge of DWI is relatively unlikely unless an accident actually happens (Benson, 2000). Drunk drivers are more likely to be escorted or driven home than arrested by police. The non-response to the severity of these punishments is unlikely to stem from irrationality or imperfect rationality, as respondents committed fewer DWI violations in response to higher perceived risks of being pulled over and accidents.

A possible limitation of our study is that the SAD did not observe respondents in actual situations when they decide whether to drink and drive, where individuals are likely to be intoxicated. However, if individuals cannot be deterred by harsher punishments when they are in “cold” state, it seems implausible that they will be deterred when they are intoxicated, as

[10] Our data suggest this is not a plausible explanation. The mean amount of fine and length of jail sentence, driver license suspension, SCRAM use and mandatory alcohol counseling time in the CASI-II survey high experiment are $1,964, 78.4 days, 19.1 months, 38.1 months, and 12.7 months, respectively, and are $1,663, 44.7 days, 18.1months, 17.0 months, and 8.6 months, respectively, in the low experiment in CASI-I survey.

tolerance towards risks tends to increase with higher blood alcohol concentration (Lane et al., 2004; Burghart et al., 2013).

To address the concerns about individuals' ability of predicting their own future behavior, we examined the predictive power of subjective probability of drinking and driving or over-speeding 15+ miles per hour at least once in the next year on the actual outcomes. As shown in Table 6, a 10 percentage point increase in the subjective probability of drinking and driving and over-speeding at least once next year would raise the actual involvement in these behaviors, respectively, by 18.7 and 3.8 percent. Thus, consistent with earlier studies (e.g.,; Finkelstein and McGarry, 2006; Hurd, 2009; Insler, 2014), these results imply that individuals' subjective probabilities can indeed predict future actual outcomes.

IV. Conclusion

We find that risk perceptions of being pulled over and involved in accidents as a consequence of driving under the influence of alcohol are deterrents of drinking and driving. However, these deterrent effects are limited to persons who are alcohol addicted, lack self-control over drinking, and are more impulsive in general. We provide a possible explanation for this pattern of findings: the groups of individuals who are more responsive to changes in subjective beliefs face higher costs of incurring the adverse outcomes of drinking and driving. We find no deterrent effects of sanction severity in terms of amount of fine, and length of jail sentence, license suspension, SCRAM use and mandatory alcohol counseling on frequency of drinking and driving. The effectiveness of harsher punishments may be limited by their partial coverage, i.e., low probability of receiving these sanctions if drinking and driving.

Although our results suggest deterrent effects of risk perceptions of being pulled over and being involved in an accident on drinking and driving behaviors, the perceived risks of being pulled over are substantially higher than their objective counterparts.[11] Therefore, programs designed to manipulate beliefs of being pulled over would seem to be an inappropriate way for reducing driving under the influence of alcohol. However, being informed of the actual increase in risk of having an accident may be a more promising approach. 92.84 percent of respondents reported an increase in the accident probability of lower than 100 percent when driving

[11] A trend consistent with earlier studies, e.g., Lochner (2007) in the context of crime, Viscusi and Evans (1990) on adverse health effects of chemicals.

intoxicated compared with driving while sober. Levitt and Porter (2001) concluded that drivers with alcohol involvement but not necessarily legally drunk pose a risk of seven times greater than sober drinkers to cause a fatal crash; drivers above the blood-alcohol limit of 0.10 are 13 times more likely to be the cause of fatal crashes. These results suggest that information campaign may seek to influence drivers' perceptions of accident risks to reduce DWI violations.[12]

Harsher sanctions to drinking and driving may generate no marginal deterrent effect if drivers' perceived risks of receiving the punishments are low. Therefore, rather than escalating sanction severity, increasing the probability of detection and/or enforcement may be more effective in reducing drinking and driving.

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[12] Although one caveat here is that since we are identifying across-individual variation in perceived risks of being involved in accidents, it is not absolutely clear that the within-person change in this information would cause the same behavior change in drinking and driving.

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Table 1. Summary Statistics

Variables	Restricted Sample		Total Sample		T-test Restricted vs. Other
	Mean	Std. Dev.	Mean	Std. Dev.	
No. DWI	1.881	2.157	1.053	1.821	***
CASI-I Pull Over Prob. (%)	17.034	18.636			
CASI-I Accident Prob. Increase (%)	43.478	38.365			
CASI-II Year Pull Over Prob. (%)	18.928	19.130			
CASI-II Year Pull Over Prob. for Third Person (%)	10.082	12.852			
CASI-II Year Accident Prob. Increase (%)	41.295	40.780			
Age (Year)	41.674	11.676	43.035	12.574	***
Female	0.463	0.499	0.542	0.498	***
Black	0.093	0.291	0.114	0.318	*
Married	0.440	0.497	0.462	0.499	*
Education (Year)	15.687	1.936	15.602	1.935	
Household Income (1,000$)	79.392	62.062	77.181	62.315	
CAGE=0	0.311	0.463	0.382	0.486	***
CAGE=1	0.263	0.441	0.237	0.426	**
CAGE=2	0.243	0.429	0.207	0.405	**
CAGE=3/4	0.182	0.387	0.174	0.379	**
Current Smoker	0.163	0.370	0.161	0.368	
Hard Drug User	0.170	0.376	0.149	0.356	***
Speed 15 mph	0.274	0.446	0.237	0.425	***
Cognition Index	12.081	1.212	11.974	1.309	*
Self-Control: Very Easy	0.431	0.496	0.586	0.493	***
Self-Control: Somewhat Easy	0.433	0.496	0.314	0.464	***
Self-Control: Somewhat Difficult	0.123	0.329	0.089	0.285	***
Self-Control: Very Difficult	0.013	0.111	0.011	0.105	
Impulsivity Index	30.487	6.683	29.756	6.629	***
Risk Tolerant=0.15	0.290	0.454	0.358	0.480	***
Risk Tolerant=0.28	0.544	0.499	0.494	0.500	***
Risk Tolerant=0.35/0.57	0.166	0.373	0.148	0.355	*
Financial Planning Horizon (Year)	4.108	3.651	4.252	3.695	
Observations	559		1,359		

Notes: *p<0.1, **p<0.05, ***p<0.01. The t-tests are between values from the restricted sample and the total sample less the restricted sample.

Table2. Effects of Risk Perceptions on Number of Drinking and Driving Episodes/Year

	OLS			IV
Variables	(1)	(2)	(3)	(1)
Pull Over Prob.	-0.012***	-0.010*	-0.013***	-0.016**
	(0.004)	(0.005)	(0.005)	(0.008)
Accident Prob. Increase	-0.006***	-0.006***	-0.006***	-0.010**
	(0.002)	(0.002)	(0.002)	(0.005)
Age	-0.005	-0.005	-0.012	-0.012
	(0.007)	(0.009)	(0.009)	(0.009)
Female	-0.773***	-0.758***	-0.651***	-0.568***
	(0.162)	(0.184)	(0.184)	(0.194)
Black	-0.538**	-0.396	-0.254	-0.265
	(0.220)	(0.280)	(0.295)	(0.288)
Married	-0.620***	-0.624***	-0.308	-0.278
	(0.180)	(0.215)	(0.221)	(0.219)
Educational (Year)	-0.113**	-0.117**	-0.050	-0.047
	(0.045)	(0.051)	(0.050)	(0.049)
Household Income (1,000$)	0.002*	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
CAGE=1			0.014	0.029
			(0.205)	(0.204)
CAGE=2			0.439*	0.425*
			(0.224)	(0.223)
CAGE=3/4			0.808***	0.800***
			(0.285)	(0.278)
Current Smoker			0.627**	0.594**
			(0.298)	(0.296)
Hard Drug User			0.431*	0.444*
			(0.250)	(0.244)
Speed 15 mph			0.248	0.247
			(0.205)	(0.200)
Cognition			0.037	0.037
			(0.068)	(0.067)
Lack Self-Control			0.708***	0.724***
			(0.273)	(0.265)
Impulsivity			0.021	0.021
			(0.015)	(0.015)
Risk Tolerance			-1.131	-1.189
			(0.921)	(0.911)
Financial Planning			0.042*	0.044*
			(0.025)	(0.024)
City Fixed Effects	No	No	Yes	Yes
Constant	4.629***	4.834***	2.266*	2.389*
	(0.768)	(0.894)	(1.294)	(1.275)
Cragg-Donald F statistic				54.337
Kleibergen-Paap F statistic				29.183
Hansen J statistic				1.337
Chi-sq P-value				0.248
Observations	694	559	559	559

*** p<0.01, ** p<0.05, * p<0.1

Table 3. Variation in Deterrent Effects of Risk Perceptions by Group

Variables	CAGE =0	CAGE =1,2,3,4	Self-Controlled	Lack Self-Control	Less Impulsive	More Impulsive
Pull Over Prob.	-0.015	-0.016*	-0.006	-0.021*	-0.014	-0.025**
	(0.012)	(0.009)	(0.009)	(0.012)	(0.010)	(0.013)
Accident Prob.	-0.003	-0.019***	-0.002	-0.020***	-0.006	-0.014
Increase	(0.007)	(0.006)	(0.007)	(0.006)	(0.005)	(0.010)
Cragg-Donald F statistic	20.577	33.489	18.635	33.590	31.901	15.277
Kleibergen-Paap F statistic	18.747	17.066	10.927	19.423	17.947	8.847
Hansen J statistic	1.452	1.998	0.592	1.646	0.219	1.279
Chi-sq P-value	0.228	0.158	0.442	0.200	0.640	0.258
Observations	174	385	241	318	315	244

*p<0.1, **p<0.05, ***p<0.01

Table 4. Costs Associated with Drinking and Driving

	CAGE =0	CAGE =1,2,3,4		Self-Controlled	Lack Self-Control		Less Impulsive	More Impulsive	
Arrest for Drunk Driving Would Almost Ruin Life									
Mean	0.069	0.166	***	0.145	0.129		0.108	0.172	**
Std. Error	(0.019)	(0.019)		(0.023)	(0.019)		(0.017)	(0.024)	
Percent Chance Will be Convicted for DWI Conditional on Being Pulled Over									
Mean	58.724	63.509	*	59.096	64.224	*	61.590	62.566	
Std. Error	(2.439)	(1.559)		(2.099)	(1.676)		(1.742)	(2.017)	
Amount of Fine ($)									
Mean	905.471	1070.627		1006.489	1097.945		1114.223	894.668	**
Std. Error	(90.508)	(67.293)		(57.350)	(163.978)		(78.815)	(70.655)	
Amount of Jail Time to Serve (Day)									
Mean	42.472	40.304		43.644	23.494		34.668	49.185	
Std. Error	(15.484)	(7.061)		(7.842)	(4.928)		(3.773)	(14.952)	
Amount of Time Driver License Suspended (Month)									
Mean	8.652	9.864		9.753	7.775		9.756	9.137	
Std. Error	(0.758)	(0.596)		(0.537)	(0.654)		(0.710)	(0.582)	
Amount of Time Ordered to Use SCRAM device (Month)									
Mean	13.855	12.979		12.842	15.907		13.731	12.623	
Std. Error	(1.674)	(0.663)		(0.608)	(3.369)		(1.094)	(0.710)	
Amount of Time to Attend Alcohol Counseling (Month)									
Mean	4.486	4.809		4.848	3.805		5.128	4.169	
Std. Error	(0.394)	(0.419)		(0.356)	(0.399)		(0.513)	(0.275)	
Observations	174	385		241	318		315	244	

Notes: *p<0.1, **p<0.05, ***p<0.01

Table 5. Deterrent Effects of Sanction Severity on Subjective Probability of Drinking and Driving

Variables	Fine	Jail Time	License Revoked	Scram	Alcohol Counseling
Panel A: Treat Dependent Variables as Continuous					
Sanction Severity	-5.926	2.194	-4.937	-2.751	2.594
	(3.810)	(2.293)	(3.463)	(2.488)	(3.316)
R-squared	0.048	0.061	0.040	0.052	0.041
Panel B: Grouping Dependent Variables					
Sanction Severity	-0.217	-0.060	-0.181	-0.115	0.107
	(0.132)	(0.081)	(0.119)	(0.089)	(0.119)
R-squared	0.080	0.108	0.071	0.078	0.060
Observations	908	726	884	770	904

Note: *p<0.1, **p<0.05, ***p<0.01

Table 6. Ability of Subjective Beliefs in Predicting Actual Outcomes

Variables	Actual Drinking-Driving	Actual Over-speeding Citation
Subjective Probabilities	1.868***	0.379**
	(0.185)	(0.170)
Pseudo R-squared	0.233	0.081
Observations	1109	1088

Notes: 1) covariates also include age, gender, being black, being married, educational years, household income, alcohol addiction levels measured by CAGE, whether smoker, hard-drug user and speeding, lack of self-control, impulsivity, cognition, risk tolerance, financial planning horizon, and city fixed effects;
2)*p<0.1, **p<0.05, ***p<0.01

Appendix Table 1. First Stage Results and Effects of Residuals on Number of Drinking and Driving Episodes/Year

	CASI-I Pull Over Prob.	CASI-I Accident Prob.	No. Drinking Driving
Instruments			
CASI-II Pull Over Prob.	0.543***	0.081	
	(0.045)	(0.077)	
CASI-II Third Person Pull Over Prob.	0.200**	0.061	
	(0.079)	(0.092)	
CASI-II Accident Prob. Increase	0.007	0.466***	
	(0.019)	(0.046)	
Predicted Residuals from First Stage			
Pull Over Residual			0.005
			(0.010)
Accident Residual			0.006
			(0.006)
Observations	559	559	559

Notes: 1) *p<0.1, **p<0.05, ***p<0.01

2) covariates also include age, gender, being black, being married, educational years, household income, alcohol addiction levels measured by CAGE, whether smoker, hard-drug user and speeding, lack of self-control, impulsivity, cognition, risk tolerance, financial planning horizon, and city fixed effects;

Appendix Table 2. Difference in Baseline Beliefs of Adverse Consequences across Waves

	CASI-I	CASI-II	t-test (*p*-value)
Sanction Severity			
Amount of Fine	1037.204	1036.955	0.997
	(56.327)	(57.394)	
Length. Jail Sentence	27.815	28.426	0.924
	(3.491)	(6.151)	
Length. License Suspension	11.257	9.275	0.445
	(2.696)]	(0.639)	
Length. SCRAM Use	10.590	13.560	0.336
	(0.494)	(3.116)	
Length. Alcohol Counseling	5.392	5.726	0.713
	(0.841)	(1.057)	
Pullover and Accident Risks			
Prob. Pulled Over	17.034	18.928	0.008
	(0.788)	(0.809)	
Increase Accident Prob.	43.478	41.295	0.008
	(1.623)	(1.725)	

Appendix Table 3. Heckman Selection: Effects of Risk Perception on DWI Behaviors

VARIABLES	OLS	IV
Pull Over Prob.	-0.013***	-0.015**
	(0.005)	(0.008)
Accident Prob. Increase	-0.006**	-0.010**
	(0.002)	(0.005)
Age	-0.010	-0.010
	(0.008)	(0.009)
Female	-0.559**	-0.496**
	(0.222)	(0.222)
Black	-0.225	-0.244
	(0.304)	(0.292)
Married	-0.282	-0.256
	(0.208)	(0.220)
Educational (Year)	-0.059	-0.054
	(0.050)	(0.050)
Household Income (1,000$)	0.002	0.002
	(0.002)	(0.001)
CAGE=1	-0.046	-0.019
	(0.238)	(0.219)
CAGE=2	0.371	0.370
	(0.248)	(0.238)
CAGE=3/4	0.779***	0.778***
	(0.266)	(0.280)
Smoking	0.659**	0.618**
	(0.256)	(0.298)
Hard Drug User	0.404*	0.424*
	(0.240)	(0.244)
Speeding	0.237	0.238
	(0.193)	(0.202)
Cognition	0.025	0.027
	(0.076)	(0.069)
Lack Self-Control	0.632**	0.662**
	(0.274)	(0.285)
Impulsivity	0.016	0.018
	(0.015)	(0.016)
Risk Tolerance	-1.367	-1.369
	(0.962)	(0.975)
Financial Planning	0.042*	0.044*
	(0.024)	(0.024)
City Fixed Effects	Yes	Yes
Lambda	-0.351	-0.277
	(0.480)	(0.456)

Observations	1,134	559

Notes: 1) *p<0.1, **p<0.05, ***p<0.01; 2) column 1 directly uses Heckman selection regression in Stata, the independent variables in the selection equation include age, gender, black race, marital status, educational years, household income, binary variables for CAGE=1 or 2 or 3/4, whether hard drug user, self-control over drinking, impulsivity, cognition, risk tolerance, financial planning horizon, state fix effects, and benefits of drinking. Column 2 first run a probit regression of respondents' probability of being included the restricted sample, and then incorporate computed inverse Mills ratio as an additional control in the IV regression.