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HOW EFFICIENT ARE THE CURRENT U.S. BEER TAXES?

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Summary

Alcohol taxes can be used to cover external costs associated with alcohol consumption and lower instances of market failure. Federal alcohol taxes have not been raised since 1991 and since then only a handful of states have opted for state-level increases in alcohol taxes. Thus, the real prices and taxes on alcohol in the U.S. have declined overtime.

A-priori it is not clear as to weather a heavy drinker imposes any additional net external costs to a society. For example, heavy drinking can lead to higher medical costs. Consequently, premature death due to heavy drinking may induce a heavy drinker to cross-subsidize his Medicare and social security share to a non-heavy drinker.

This paper evaluates the status of current U.S. beer taxes by comparing the current level of excise taxes on beer with the optimal beer taxes. I conduct two main exercises. First, I calculate tax elasticity of alcohol consumption. Second, I estimate the lifetime discounted costs that a heavy drinker impose on others through: 1) Years of life lost, 2) Social insurance system, 3) Drunk driving accidents, and 4) Forgone income taxes.

Two studies have evaluated the optimal level of alcohol taxes. Pogue and Sgontz (1989) present a wide estimate of alcohol tax rate ranging from 19 to 306 percent. Kenkel (1996) finds that the optimal tax rate is over 100 percent of the net-of-tax price and emphasizes alcohol taxes as a second best option. Both studies implement a cross-sectional approach, provide an outdated version of alcohol-related costs, and do not breakdown the medical costs borne by the social insurance system.

This study uses a life-time approach to provide new estimates of the optimal level of beer taxes. I find that the optimal level of beer taxes ranges from 17.15 percent to 47.5 percent of the price per beer. Even the conservative estimates suggest that current beer taxes comprise only 16 percent of the external costs. These findings inform policymakers by indicating that higher beer taxes can improve welfare of a society.

HOW EFFICIENT ARE THE CURRENT U.S. BEER TAXES?

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Abstract

This paper examines the status of current beer taxes in the U.S. by questioning how far away the present beer taxes are from the optimal taxes. Following the estimation of tax elasticity, I estimate the lifetime discounted costs that a heavy drinker levies on others through: 1) Years of life lost; 2) Social insurance system; 3) Drunk driving accidents; and 4) Forgone income taxes. The optimal level of beer tax ranges from 17.15 percent to 47.5 percent of the price per drink. Even the conservative estimates suggest that current beer taxes comprise only 16 percent of the external costs.

Key Words: Externality, Beer Taxation, Efficiency

JEL Codes: H210, H230, I100

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1. Introduction

Federal alcohol taxes have not been raised since 1991 and since then only a handful of states have opted for state-level increases in alcohol taxes. The real prices and taxes for beer have plummeted over recent decades. Although past studies suggest that moderate and light drinking can be beneficial to health, alcohol-related tragedies such as drunk driving, crime, and liver cirrhosis are well documented. From a Pigovian viewpoint, alcohol taxes can be used as a medium to cover not just the internal, but also the external costs of alcohol consumption. The lack of initiative shown by policymakers to raise alcohol taxes leads one to question the current status and role of alcohol taxes in the United States.

There are two main reasons that may explain a policymaker's reluctant attitude towards raising alcohol taxes. The first one is the lobbying power established by the beer companies. The second one can possibly be attributed to political convenience. Greenfield et al. (2007) suggest that drinking sentiments have increased in past decades. Higher alcohol taxes would not only increase prices for heavy drinkers but also for light and moderate drinkers, who constitute a majority of the population. Hence, increasing alcohol taxes may lead to additional political costs than, for example, a tax increase in cigarettes.

From an economic perspective, the failure to adequately tax alcohol may promote behaviors that lead to inefficient decisions. Although the needs for alcohol taxes are clear, how well the current level of alcohol taxes perform in addressing the external costs associated with heavy drinking is theoretically ambiguous. Given that heavy drinking leads to higher medical costs, these costs may be borne by the social insurance systems, such as Medicaid and Medicare. However, if heavy drinking leads to premature death, heavy drinkers may cross-subsidize their

Medicare and social security shares to non-heavy drinkers. A priori, it is not clear as to whether a heavy drinker imposes any additional net external costs to a society.

This study estimates the optimal level of beer taxation in the United States. I first estimate price elasticity for both moderate and heavy drinkers by utilizing the recent tax changes and using data from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1996 to 2007. I use data from the National Health Interview Survey (NHIS) linked with National Vital System Statistics (NVSS) and the Medical Panel Survey (MEPS to estimate the lifetime costs imposed by a heavy drinker on others in terms of years of life lost, Medicaid and Medicare, and drunk driving accidents, respectively. To account for differences in how a person values the future than the present, costs are discounted by using a discount rate of 3 percent at 18 years of age. I use the findings established by Sloan and Ostermann (2004) to determine the cost of heavy drinking on social security outlays. I utilize the framework of optimal alcohol taxation established by Pogue and Sgontz (1989) to estimate the optimal level of alcohol taxes.

I find that a heavy drinker does not pay his/her way out at the current level of beer taxes. The level of beer taxes in 2015 at $0.073 per drink covers (converted to 2009 dollars) approximately covers 16 percent of the external costs associated with drinking. Findings from the benchmark model, which declares with certainty that a heavy drinker will suffer from alcohol-related diseases (ALD), suggest that an optimal level of beer taxes is $0.63 per drink. After making an adjustment to the probability of a heavy drinker suffering from ALD, the findings suggest $0.23 per drink as an optimal level of beer taxes. The calculation to obtain such an estimate uses conservative values and represents an estimate towards a lower range. Failing to consider costs due to alcohol-related liver cirrhosis puts the optimal level of beer taxes at $0.20. The overall findings of this study recommend an increase in alcohol taxes for taxes to be effectively used as a mechanism to internalize the external costs associated with alcohol consumption.

Two previous studies have evaluated the optimal level of alcohol taxes. Pogue and Sgontz (1989) present a wide estimate of the alcohol tax rate ranging from 19 to 306 percent and claim 51 percent as their best-guess estimate. Kenkel (1996) extends the framework of Pogue and Sgontz (1989) to narrow the range of the alcohol tax rate and finds that the optimal tax rate is over 100 percent of the net-of-tax price. However, the author emphasizes alcohol taxation as the second best option, concluding that the level of alcohol taxes would be much lower if the punishment for drunk driving were more severe. A seminal study by Pogue and Sgontz (1989) assumes that the price elasticity of both moderate and heavy drinkers is the same. Consequently, the study provides an outdated version of costs related to alcohol consumption, does not break down the medical costs borne by the social insurance system, and exclude estimates of years of life lost due to heavy drinking when calculating the optimal taxes.

2. Framework and Assumptions

The framework for optimal taxation follows from Pogue and Sgontz's (1989) seminal paper. To begin, I assume that there are two types of consumers — moderate drinkers and heavy drinkers who are more liable to create alcohol-related risks. Figure 1 shows the demand schedule for light and heavy drinkers. Here, D_h represents the demand curve for heavy drinkers and D_l pertains to moderate drinkers. For simplicity, I assume that there is only one alcoholic beverage that is produced in a competitive market at a constant marginal cost of production. The optimal level of taxation would vary depending on the type of alcoholic beverage (beer, wine, spirits). Unfortunately, it is impossible to identify the exact type of beverage consumed given the data. According to a report from the National Institute on Alcohol Abuse and Alcoholism, beer comprises more than half of the ethanol consumption in the United States (approximately 54 percent of per-capita ethanol consumption in 2006) and stands as a most prevalent form of alcoholic beverage consumed in the country.[1] Given this fact, this study focuses on beer taxes.

An assumption in a competitive market is that higher alcohol taxes are fully passed through as alcohol prices. However, market for beer can be best categorized as an oligopoly. Kenkel (2005) provides evidence that alcohol taxes are more than fully passed through as prices in Alaska. Similarly, Young and Kwapisz (2002) suggest that excise taxes on beer are more than fully passed-through. In a recent study, using the data from 2000 to 2014, Shrestha and Markowitz (2015) provide evidence that consumer fully bear the burden of increases in beer taxes. Specifically, I estimate tax elasticity more so than price elasticity for both moderate and heavy drinkers. A tax elasticity of -0.5 would precisely suggest that an increase in alcohol taxes by 1 percent leads to a reduction in alcohol consumption by 0.5 percent. Two main advantages of using taxes in favor of prices are: 1) Taxation is a key policy instrument and tax elasticity directly corresponds to optimal taxation; and 2) Taxes reduce an issue of measurement error present in prices, which can downward bias the estimate of price elasticity.[2]

Figure 1 also shows the price and marginal social cost. The difference between price P and the marginal social cost represents the marginal external cost of alcohol consumption, which is negligible for moderate drinkers but increases with an increase in alcohol consumption. When the price of alcohol is P, heavy drinkers consume x_a amounts of alcohol; whereas, light drinkers consume x_b. For heavy drinkers, the marginal social cost at the point of consumption (x_a) is greater than the marginal benefit, which leads to market inefficiency if external costs are not

[1] Source: http://pubs.niaaa.nih.gov/publications/surveillance85/CONS06.pdf

[2] Using taxes instead of prices would be problematic if beer taxes were not fully passed-through as prices. However, the pass-through literature suggest that excise taxes of beer are at least fully passed through as retail prices.

considered. Alcohol taxes T can allow a heavy drinker to internalize the amount of external costs imposed by a heavy drinker; thus, leading towards an efficient level of alcohol consumption at x_A for heavy drinkers. However, a light drinker reduces alcohol consumption to x_B. The welfare gain due to higher alcohol taxes is represented by the reduction in social cost (area h) among heavy drinkers and the loss in consumer surplus experienced by light drinkers (area l) as the deadweight loss. The welfare gain can be written as:

$$W = (x_a - x_A) * E * n - (x_a - x_A) * \frac{T}{2} * n - (x_b - x_B) * \frac{T}{2} * (1 - n), \qquad (1)$$

where the first two combined terms represent the welfare gain achieved when heavy drinkers reduce their alcohol consumption. The third term represents the loss in consumer surplus for moderate drinkers due to the imposition of alcohol taxes. The proportion of heavy drinkers in a population is represented by n.

The assumption that taxes are fully passed through as prices yield

$$(x_a - x_A) = \eta_h * \frac{T}{P} * x_A, \qquad (2)$$

where η_h represents the price elasticity of demand for heavy drinkers. A similar equation can be obtained for light drinkers. Substituting equation (2) into equation (1) gives the following equation:

$$W = \left\{\eta_H * \frac{T}{P} * x_a * E * n\right\} - \left\{\eta_H * \frac{T}{P} * x_a * \frac{T}{2} * n\right\} - \left\{\eta_l * \frac{T}{P} * x_b * \frac{T}{2} * (1 - n)\right\}. \qquad (3)$$

To find the optimal taxation, the first-order condition to maximize social welfare with respect to T yields

$$t = \frac{T}{P} = \frac{E}{P}\left\{\frac{1}{1 + \frac{\eta_l}{\eta_h}\frac{X'_B}{X'_A}}\right\} \qquad (4)$$

In equation (4), E represents the external costs associated with drinking, T is the optimal amount of tax in dollars per drink, $\frac{\eta_l}{\eta_h}$ is the relative price elasticity of the risky and non-risky drinkers, and $\frac{X'_B}{X'_A}$ is relative drinks consumed by light and heavy drinkers, where $X'_A = x_a * n$ and $X'_B = x_b * n$. Equation (4) gives the optimal tax rate on a given price P. The given equation suggests that the amount of tax is directly proportional to the external costs and inversely related to the relative prices elasticity of moderate versus heavy drinkers. In other words, if heavy drinkers are more responsive to higher alcohol prices compared to moderate drinkers, then the optimal level of alcohol taxes is increased.

3. Estimating the Price Elasticity of Demand for Moderate and Heavy Drinkers

3A. Data

3A.1. Behavioral Risk Factor Surveillance System (BRFSS)

Data on alcohol consumption and other individual characteristics come from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1996 to 2007. BRFSS comprises nationally representative samples of individuals with a comparatively large sample size. Questions asked in the survey reflect the drinking behavior of an individual, such as the number of days an individual drinks in a month, the average number of drinks a respondent consumes while he/she drinks, and the number of days in a month an individual participates in heavy drinking. To capture the overall drinking behavior, the number of drinks a person consumes per month is used as the dependent variable. It is a calculated variable constructed by multiplying the number of days an individual drinks per month and the average drinks he/she consumes while drinking.

Apart from the BRFSS sample being a nationally representative survey with a large sample size; it comprises a relatively rich set of socioeconomic and demographic characteristics, which are shown in the summary statistics table (Tables 1). The personal characteristics that this study controls for are income, age, gender, race, employment status, education, and marital status. Moreover, the respondents report their state of residence, which allows for merging the state-level variables with each observation. This study excludes observations from Puerto Rico, Guam, and the Virgin Islands, thus restricting the sample to the fifty states and the District of Columbia. Individuals with unknown age are dropped. Finally, observations with a missing value for the number of drinks consumed per month are also discarded.

3A.2. Alcohol Taxes

Data for beer taxes comes from the Alcohol Policy Information System (APIS) and the respective taxes are corroborated using the tax reported by the Tax Foundation and Brewers Almanac. Taxation serves as a direct policy instrument; hence, the results from using taxes are relevant to policymakers. However, to be able to identify the effect of higher alcohol taxes on alcohol consumption in the model that controls for the state unobserved time invariant heterogeneity, it is critical to have an adequate amount of within-state variation in alcohol taxes. From 1996 to 2007, there were ten incidences of changes in beer tax. Figure 2A shows the trend in state-level real beer taxes per gallon. Figure 2B shows the trend in nominal state-level beer taxes per gallon for the group of states that experienced tax changes and those states without tax changes. For the group of states that experienced tax changes, the average state-level nominal taxes per gallon increased by more than 10 cents between 1996 and 2007, suggesting the presence of within state variation in beer taxes.

3B. Identification Strategy

I use within-state variation in beer taxes occurring over time to identify the effect of higher alcohol taxes on alcohol consumption. I use a two-part model similar to Manning et al. (1995) to model alcohol consumption. The two-part model is used for three reasons: 1) Significant proportion of individuals in the sample reported having not consumed any alcoholic beverage in the past month (approximately 45 % of 18-to-24 year-olds), 2) Drinkers have a right skewed distribution for monthly number of drinks consumed, which is approximately log normal (for 18-to-24 year-olds); and 3) The two-part model presents some behavioral appeal as responsiveness to price can be estimated in an extensive and intensive margins. The first part models an individual's participation decision (decision to drink) and the second part models one's intensity of alcohol consumption, given that the person consumed alcohol. The first part model refers to the extensive margin and can be written as follows:

$$D_{its} = \alpha + \beta_a \log(tax_{ts}) + \mu X_{its} + \delta Z_{ts} + \eta_t + \theta_s + \varepsilon_{its}, \qquad (5a)$$

Here, D_{its} is a binary variable taking a value of "1" if an individual i, surveyed in year t, and from state s participates in drinking (or heavy drinking). Tax is the real beer tax (per gallon) converted to 2006 dollars, X is individual-specific characteristics, and Z pertains to the state-specific characteristics. The specification controls for the year fixed effects represented by η, which captures the common characteristics of all the states that vary over time, and θ_s are the state fixed effects. Following Manning et al. (1995), I estimate the first part model using a logistic functional form. Robust standard errors clustered at the state level are presented.

Given that an individual participates in drinking, I estimate the second part model as follows:

$$\log(A_{its}) = \alpha + \beta_b \log(tax_{ts}) + \mu X_{its} + \delta Z_{ts} + \eta_t + \theta_s + \lambda_s + \varepsilon_{its}, \qquad (5b)$$

where A is a variable capturing an intensity of drinking behavior (number of drinks per month) of an individual i, surveyed in year t, and from state s, and other variables specified as similar to those in equation (5a).

Since alcohol-related externalities are prevalent among heavy or risky drinkers, I evaluate the differential effects of increases in beer taxes on alcohol consumption. Similar to Manning et al. (1995), I use a quantile regression method first introduced by Koenker and Basset (1978). While the estimate of β in equation $(5b)$ represents the price elasticity of demand for alcohol at the conditional mean, use of a quantile regression method allows the responsiveness due to increases in beer taxes to vary across the conditional distribution of alcohol consumption. The τ^{th} conditional quantile function is specified as:

$$\log(A_{its}) = \alpha_\tau + \beta_\tau \log(tax_{ts}) + \mu_\tau X_{its} + \delta_\tau Z_{ts} + \eta_{t\tau} + \theta_{s\tau} + \varepsilon_{its}, \qquad (5c)$$

where, the coefficient of interest is β_τ, which is a price elasticity estimate at the τ^{th} conditional quantile. For the coefficients pertaining to the quantile regression, bootstrap standard errors are estimated from 99 replications.

Following Manning et al. (1995), the price elasticity of demand from the two-part model can be written as:

$$Elasticity = (1 - P)\beta_a + \beta_b \qquad (5d)$$

where, P is the proportion of current drinkers, and β_a and β_b are the coefficients on $\log(tax_{ts})$ for the first part and second part, respectively. Note that $(1 - P)\beta_a$ corresponds to price elasticity at the extensive margin.

3C. Results (Tax Elasticity of Demand for Beer)

Table 2 presents the elasticity estimates obtained from the first and second-part model, which is estimated by both the OLS and quantile regression method. The results from the first-part model shows the marginal effects obtained from the logistic regression. The coefficient on log of beer tax suggests that a percentage increase in beer taxes is associated with a reduction in the drinking participation by 4.5 percentage points and is significant at a 5 percent level. This translates to an elasticity estimate at the extensive margin of -0.083. The second-part model estimates the conditional elasticity of demand among drinkers. The OLS estimate suggests that a one percent increase in beer tax is associated with a reduction in alcohol consumption by 0.038 percent; however, the coefficient is imprecisely estimated. The estimates from the quantile regression method paints a more detailed picture. The conditional price elasticity estimates at the 25^{th} and 50^{th} conditional quantiles are close to zero and statistically insignificant at the conventional levels. However, the conditional elasticity estimate at the 75^{th} conditional quantile is -0.125 and is significant at a 5 percent level. The quantile regression estimates suggest that relatively heavy drinkers are more responsive to increases in beer taxes. Such findings are consistent with results from Shrestha's (2015) study, which shows that heavy drinkers are responsive to increases in alcohol prices.

The unconditional elasticity estimates are shown in brackets in Table 2, which are calculated by following equation$(5d)$. The unconditional elasticity estimates suggests that heavy drinkers are relatively more responsive to increases in alcohol prices compared to light drinkers. These results help understand the welfare implication of increases in beer taxes. As previously mentioned, if increases in beer taxes reduce alcohol consumption among light drinkers, who are less prone to invoke alcohol-related externalities, higher beer taxes will lead to a deadweight loss and possibly lead to no welfare gain; thus reduce overall welfare. However, the findings in Table

2 indicates that light or moderate drinkers are non-responsive to increases in beer taxes. In contrast, heavy drinkers reduce their alcohol consumption as a result of higher beer taxes. Since, alcohol related externalities are associated with heavy drinkers rather than light drinkers, increases in beer taxes can be welfare enhancing as it lowers alcohol consumption among heavy drinkers. The result that heavy drinkers are more responsive to increases in beer prices lends support in using beer taxes as a medium to reduce alcohol-related externalities.

4. The External Cost of Heavy Drinking

Heavy drinkers impose costs not only on themselves but also for other individuals not participating in heavy drinking. The costs borne by heavy drinkers themselves are termed as internal costs; whereas, external costs are imposed on others. One obvious example of an external cost is damages caused by drunk driving. The other cases of external costs can be subtle; for example, higher medical costs in the form of health expenses. Often insurance premiums and taxes paid by heavy drinkers and light/moderate drinkers are similar after controlling for other characteristics. Hence, light or moderate drinkers may be subsidizing costs associated with heavy drinking. In contrast, if heavy drinking lowers life expectancy, then a heavy drinker might cross-subsidize moderate drinkers in forms of Medicare and pension outlays, given that a heavy drinker contributes the same amount to Medicare and Social Security taxes as a moderate drinker does.

The types of external and internal costs associated with heavy drinking are shown in Table 3, which is divided into internal and external costs. The costs imposed on family members are explicitly considered as external costs in the sense that once a heavy drinker dies, he experiences no cost; however, the burden is transferred to family members. While estimating the cost of smoking, Sloan et al. (2004) treats the costs of smoking imposed on household members as “quasi-external”, with social costs being the sum of three different costs— internal, external; and quasi-external. The following sections are dedicated to estimating costs related to heavy drinking in the following aspects: 1) Reduced life expectancy; 2) Medical expenses; 3) Alcohol-related driving accidents; and 4) Social Security benefits.

A. Effect of Heavy Drinking on Mortality (Excluding Drunk-Driving)

Figure 3 shows age-specific deaths due to alcoholic liver disease (ALD), mainly comprising of fatty liver disease, alcoholic hepatitis, and liver cirrhosis. The data is taken from the National Vital Statistics multiple cause-of-deaths. The count shows an increasing trend until age 55, after which the death tolls from ALD start declining due to the majority of heavy drinkers dying before 60 years of age. The bell- shaped curve in Figure 3 indicates that the mean age of death due to ALD is around 55 years. A total of 30,627 deaths in 2009 can be attributed to ALD. Figure 4 provides the probability of death due to ALD. The figure suggests that at the age of 50, approximately 3 deaths can be attributed to ALD for every 100 deaths.

1. Method and Data

It is not appealing to compare a heavy drinker with non-heavy drinker in terms of years of life lost as a heavy drinker may differ from a non-heavy drinker in several ways. Heavy drinkers may have a poor choice of lifestyle, indulge in smoking, and not get adequate physical exercise. For example, as heavy drinkers are more likely to smoke, not controlling for smoking status might attribute a portion of smoking- related deaths as drinking-related deaths. Instead, the comparison in terms of years of life lost should be made between a heavy drinker and a “non-drinking heavy drinker.” The concept of non-drinking heavy drinkers can be defined as a hypothetical group of people who are similar to heavy drinkers in terms of all other characteristics expect heavy drinking.[3]

A method used in this study applies a period life table technique provided by the Centers for Disease Control and Prevention (CDC) to estimate the mortality experience of an actual birth cohort. A hypothetical cohort of 2009 is selected. The assumption imposed is that a person experiences an age-specific death rate that is prevalent for the actual population in 2009. Ideally, a researcher would want to use a cohort life table where a specific cohort is followed over time to estimate the age specific death rate. However, such a procedure would require data collection over many years and is usually unfeasible. The concept of a hypothetical cohort provides a picture of age-specific mortality at a given period of time (National Vital Statistics, volume 62, number 7).

I first create a life table estimate for non-heavy drinkers by using the life table estimates provided by the National Vital Statistics Report (2009). The life table estimates presented by the CDC provides the survival probability jointly for both non-heavy and heavy drinker. To isolate the death cases associated with heavy drinking, I refer to the multiple causes-of-death mortality data from the National Vital Statistics System and eliminate the cases of age-specific drinking-related deaths from the life table provided by the CDC.[4]

To estimate the life table survival probabilities for heavy drinkers, I estimate the age-specific relative risk of dying for heavy drinkers compared to non-heavy drinkers. I first link the

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[3] Such a group of people is described as "controlled" heavy drinkers in Manning et al.'s study. These are people with similar characteristics to heavy drinkers, but consume less than three alcoholic beverages per day.

[4] Alcohol-related deaths are considered to be deaths occurring due to alcoholic liver disease. The cases of alcohol-related motor vehicle accidents are eliminated as well. The cost associated with motor vehicle accidents are considered separately.

1990 National Health Interview Survey (NHIS) data with 1990-2004 mortality files, which provides the causes and dates of the deaths of same individuals surveyed in 1990. Using a probit regression, I estimate the probability of an individual interviewed in 1990 dying between 1990 and 2004. The dependent variable is a binary variable that takes the value of 1 if an individual dies between 1990 and 2004 (otherwise the value is 0). The specification includes respondents' observed characteristics in 1990, such as smoking status (current smoker, former smoker, non-smoker), whether a respondent is a heavy drinker, gender, race, education, family income, body mass index, square of body mass index, and categorical variables for age intervals starting from 20 years old to 100 with the length of each interval being 10 years. Here, heavy drinkers are defined as those drinking 3 or more drinks per day. To allow the effect of smoking and drinking to vary with age in a non-linear way, the specification also includes the interaction terms of categorical variables for age with indicators of whether a person is a current smoker, former smoker, and heavy drinker. I estimate the predicted probability of dying between 1990 and 2004 for non-heavy drinkers and heavy drinkers at the respective means for these two groups. I form a measure of age-specific relative risk of dying for heavy drinkers compared to non-heavy drinkers by dividing the predicted probability of dying for heavy drinkers by the predicted probability of dying for non-heavy drinkers for every age interval. This provides an estimate of how likely heavy drinkers are to die compared to non-heavy drinkers. Finally, using the estimates of age specific relative risk of dying, I use the life table estimates of non-heavy drinkers to estimate the survival probability of heavy drinkers.

Similarly, I calculate the age-specific survival probability of non-drinking heavy drinkers, except that in this case the indicator variable for a heavy drinker is switched off and mean values of explanatory variables pertaining to heavy drinkers are used.[5] In this case, we can think of comparing a heavy drinker with a hypothetical heavy drinker who is similar to heavy drinkers in all characteristics except that the hypothetical heavy drinker consumes less than 3 alcoholic beverages per day.

2. Results

Table 4 shows the summary statistics of heavy drinkers and non-heavy drinkers. The table shows that heavy drinkers on average die approximately 10 years earlier than non-heavy drinkers. As expected, 50 percent of heavy drinkers smoke tobacco on a regular basis compared to 25 percent among non-heavy drinkers. As suspected, the raw comparison of life expectancy between heavy drinkers and non-heavy drinkers will overestimate the effect of heavy drinking on years lived by attributing smoking-related deaths to heavy drinking. This further highlights the importance of hypothetical non-drinking heavy drinkers in this analysis. Consistent with the literature, the incidence of heavy drinking increases with income; males and whites are prone to drink more heavily compared to females and other races, respectively.

Figure 5 presents the CDF of survival for the following three groups: non-heavy drinkers, non-drinking heavy drinkers, and heavy drinkers. The difference in survival probability between the three groups begins after 45 years of age; however, the difference between survival probabilities among all three groups is fairly consistent after 65 years of age. The probability of surviving until 70 years is 0.8, 0.72, and 0.7 for non-heavy drinkers, non-drinking heavy drinkers, and heavy drinkers, respectively. Table 5.1 shows the life expectancy at age 18 for all three groups. Compared to non-heavy drinkers, heavy drinkers on average die 6 years earlier;

[5] The survival probabilities are not shown but are available upon request.

however, the estimated effect of heavy drinking on mortality is 3 years, which is obtained after comparing heavy drinkers with non-drinking heavy drinkers. The value of life year loss discounted by 3 percent to age 18 after using a value of $100,000 per year amounts to $57,552 for a heavy drinker, as shown in Table 5.2.

Correcting for factors other than heavy drinking, such as education, smoking status, and body mass index, I estimate the number of deaths related to heavy drinking to be 11,920 for people over 50 years of age.[6] The actual number of people aged 50 years and older dying due to alcohol-related liver disease is 10,199 in 2009. The estimated number of deaths from my calculation is similar to actual deaths associated with heavy drinking.

B. Medical Expenses

The external cost of heavy drinking in terms of medical expenses can be clarified by using the following example. Assume that the cost of drinking 6 packs of beer per day raises one's medical bills by $1000; a consumer with a health insurance (Medicaid) that pays 80 percent of the medical bill internalizes $200 of the medical expenditure when he/she decides to drink. Given that the drinker does not pay a premium (taxes) large enough to cover the remaining $800, a portion of the $800 will be considered as an external cost (external cost = $800 – premium), which will possibly be borne by other members of the insurance pool.

1. Data

[6] To estimate the deaths due to alcohol, I first obtain the population of people who are above 50 from the U.S. Census Bureau. Then I estimate the proportion of people who are heavy drinkers (three or more drinks a day) by using data from the National Health Interview Survey. Finally, I use the predicted probability of dying for heavy drinkers by using data from the 1990 NHIS survey linked with the 1990-2004 mortality file to estimate the number of deaths among heavy drinkers.

To evaluate the effect of heavy drinking on medical expenses, I use data from the Medical Expenditure Panel Survey (MEPS) for the years 2000 to 2012. MEPS provides nationally representative data for health care usage; sources of payment such as private insurance, Medicare, Medicaid, and other public insurance; classification of diseases that helps to identify alcohol-related diseases; expenditures by payment types (out of pocket/family, Medicare, Medicaid, private insurance), including inpatient and outpatient service use; and socioeconomic characteristics. This study uses both the Household Component (HC) and Medical Provider Component (MPC) from MEPS. The HC of MEPS was initiated in 1996. A panel is followed for two years and each year a new panel is added into the survey. The households selected in the MEPS are a subset of households participating in the preceding survey of the National Health Interview Survey (NHIS).

The households participating in MEPS are asked for permission to contact their medical providers for information that the respondent may not be able to provide accurately. MPC provides information regarding "dates of visits, diagnosis and procedure codes, charges, and payments (MEPS HC-102F, document file)." The Pharmacy Component (PC), a subcomponent of the MPC, collects information regarding the drugs associated with diseases, sources, and expenses. Information provided in the MEPS is beneficial in estimating the comprehensive medical expenses associated with alcohol-related diseases.

Unlike smoking, deaths due to long-term alcohol use are relatively precise. MEPS data is fruitful in this aspect as it provides detailed information regarding the classification of diseases following the ICD9 codes, inpatient and outpatient expenses, pharmacy costs, and sources of payments. I use expenses related to cirrhosis of the liver as a proxy for alcohol-related medical expenses. Liver cirrhosis is the end stage of alcoholic liver disease (ALD), a serious and potentially fatal consequence of heavy drinking, and encompasses three conditions: fatty liver disease, alcoholic hepatitis, and cirrhosis. Often, alcoholic hepatitis and liver cirrhosis can coexist together. A person with both alcoholic hepatitis and cirrhosis has a death rate of more than 60 percent with most of the deaths occurring before the first year (Chedid et al., 1991).

2. Method and Results

An ideal way to estimate medical costs associated with heavy drinking is to randomly assign the trait of heavy drinking across the sample of analysis and follow individuals over time to trace the use of medical services. Such an experiment is unethical. The second alternative is to use a counterfactual analysis for heavy drinkers and non-drinking heavy drinkers similar to Solan et al. (2004) did in the case of smoking. However, MEPS does not include variables regarding alcohol consumption. The third alternative is to directly estimate medical expenses related to alcoholic liver diseases (ALD) at a given point of time.[7] Alcohol-related diseases are relatively more precise to identify when compared to smoking- related illnesses. Using liver cirrhosis, a form of alcoholic liver disease, which is a consequence of heavy drinking over a long period of time, I estimate the expenses related to heavy drinking by different payer types.

Table 6 presents descriptive statistics from the MEPS data for years 2000 to 2012 at a given point in time. The results from Table 6 suggest that patients with liver cirrhosis have a higher amount of medical expenses of all forms except family expenses compared to individuals without liver cirrhosis. Focusing at the logarithmic value of expenses, it can be deduced that such a difference in raw expenses are largely driven by a substantial mass of zero values among

[7] This process may underestimate expenses related to heavy drinking if heavy drinking increases the risk of other illnesses that are not directly related to heavy drinking. If anything, this will underestimate the external costs associated with heavy drinking.

individuals without liver cirrhosis. The average age of individuals with liver cirrhosis is 55. Figure 6 shows a kernel density plot of alcoholic liver disease by age, which mimics Figure 3 (except for small sample size); thus suggesting that both the incidence and deaths from alcoholic liver disease peaks between ages 50 to 60. Perhaps, one would expect a lag in deaths due to alcoholic liver disease after being diagnosed with the disease. However, patients with liver cirrhosis and alcoholic hepatitis (two forms of alcoholic liver disease) have a death rate of 60 percent over 4 years with the majority of deaths occurring before the first year.

According to the National Vital Statistics Report of the NCHS, 30,627 deaths occurred in 2009 due to liver cirrhosis. Table 7.1 shows the breakdown of total expenses per event according to various sources of payments per event by using the 30,627 cases of liver cirrhosis. Medicaid constitutes the largest sum of payments per event amounting to approximately $221 million, followed by private insurance totaling $144 million, and Medicare totaling $69 million. The total medical cost of alcohol liver disease to the social insurance system (per event) is approximately $296 million a year. Table 7.2 shows the respective costs by payer type discounted to 18 years old and expenses are reported in 2009 dollars.

To estimate the cost of ALD, I treat data from MEPS as a period life table that presents the estimates of medical expenses to a hypothetical cohort if it experiences relevant conditions at a given point of time throughout the course of a lifetime. For example, using the MEPS data for the years 2000 to 2010, the hypothetical cohort analysis assumes that conditions governing liver cirrhosis and medical expenses for 35 to 55 year olds and 65 to 75 year olds are similar. Figure 7 shows an abridged version of medical costs associated with liver cirrhosis plotted along the average age of the various age groups for different payer types. Figure 7 shows that family expenses related to liver cirrhosis are negligible throughout the lifetime. Medicaid expenses are

$4,000 for 45 to 50 year olds per event visit, and decreases with age. In contrast, private insurance expenses show an opposite trend peaking at close to 60 and decreasing after 60. Decreases in both Medicaid and private insurance expenses can be explained by an increasing trend in Medicare expenses after age 60 with people switching from Medicaid and private insurance to Medicare. The medical expenses adjusted by survival probabilities for a heavy drinker and discounted to 18 years of age are shown in Table 7.3. The table shows that Medicaid and private insurance covers approximately $2,000 per hospital visit. The reason why Medicare expenses are lower is because of the discounted value and the decline in survival probability of a heavy drinker after age 65. As an external cost associated with heavy drinking, I add the costs associated with Medicare and Medicaid, which sums up to $3,593.96 per event ($ $53,909.4 per lifetime).[8]

C. Alcohol-Related Drunk Driving Fatalities

The cost of drunk driving fatalities are immediate in a sense that each ounce of alcohol consumed has a certain probability of leading to a drunk driving fatality or alcohol-related accident. After imbibing alcohol, if a person is not involved in drunk driving, the cost falls to zero. In other words, it is unlikely that the cost of drinking in terms of drunk driving will accrue over time. The cost of drunk driving accidents can be categorized into various components. This study focuses on four major components: 1) The value of years of life lost due to premature death; 2) Property damage from alcohol-related accidents; 3) Medical expenses arising from alcohol-related crashes; and 4) Loss in household and market productivity from an injury.

[8] A lifetime cost associated with heavy drinking is obtained by assuming that a person has a total of 15 events related to liver cirrhosis, which leads to hospital visits. The number of visits related to liver cirrhosis are allowed to vary along with the probability of suffering from liver cirrhosis.

1. Data and Results

The cases of drunk driving fatalities are not feasibly identified in NCHS. To estimate the number of deaths due to drunk driving, I use an age-specific proportion of motor vehicle fatalities attributed to drunk driving from the Traffic Safety Facts (2010), published by the National Highway Safety Traffic Administration (NHSTA).[9]

In this section I assume that there are two types of heavy drinkers: 1) Those who drink and drive; and 2) Those who choose not to drive drunk. If a heavy drinker chooses not to drink and drive, the cost associated with drunk driving is zero. Another assumption is that a drunk driving accident will induce a learning mechanism and the person involved will not drive drunk again.

The total number of drunk driving fatalities in 2009 is approximately 7,500. Given that both self-reported alcohol consumption and drunk driving is misreported at the same level, Giesman (1987) estimates 293 million occasions of drunk driving annually. According to the statistics from the National Highway Safety Administration (2011), alcohol-impaired driving fatalities declined by 40 percent from 1985 to 2009. Using a reduction in drunk driving fatalities as a proxy for the incidence of drunk driving and assuming a linear tread in reduction leads to an approximation of 175.8 million incidences of drunk driving in 2009. The average risk that an occasion of drunk driving results in death is estimated as 0.000043. Using the statistical value of life at $2 million results in an expected cost of $85 per drunk driving occasion.

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[9] Among motor vehicle fatalities, NHTSA estimates alcohol-related deaths of 17 percent for persons aged 16 and under, 18 percent for 16 to 20 year olds, 34 percent for 21 to 24 year olds, 30 percent for 25 to 34 year olds, 25 percent for 35 to 44 year olds, 21 percent for 45 to 54 year olds, 14 percent for 55 to 64 year olds, and 5 percent for 65 years and older. This includes all fatalities associated with drunk driving (i.e., innocent passengers not consuming alcohol, pedestrians, and passengers in a vehicle with a sober driver).

To incorporate other alcohol-related driving costs, such as property damages, medical expenses, and loss in productivity from an injury, I rely upon the estimates of Blincoe et al. (2014). This study provides detailed estimates of the economic costs associated with motor vehicle accidents, which include drunk driving costs. According to their estimates, the total economic costs involved with alcohol-related crashes are $50 billion where the BAC level was greater than or equal to 0.08. Their estimates are obtained by estimating the drunk driving costs for various sectors, such as medical expenses, emergency services, market productivity, household productivity, insurance administration, workplace costs, legal costs, congestion costs, and property damages. These costs comprise various levels of severity of accidents the least severe involving property damages only (PDO) and the most severe being fatal accidents. It has to be noted that the total costs associated with alcohol-related motor vehicle accidents might be overestimated as alcohol might not be the sole cause of death in all accidents. For example, if a sober but distracted driver runs into a car driven by a person with a BAC level greater than 0 at a stoplight, the accident will be recorded as alcohol-related. But in this case, the accident is equally likely to happen regardless of a person's drinking status. Focusing on costs associated with BAC levels of 0.08 or higher reduces the likelihood of overestimation as 94 percent of crashes with BACs of 0.10 or higher are estimated to be caused by alcohol (Miller, Spicer, and Levy, 1999). Blincoe et al. (2014) estimates approximately 1,612,179 accidents involving alcohol, which gives a probability of 0.0093 that a drunk driver is involved in some form of accident. Following this, an average cost per alcohol-related accident of $ 31,000 (total cost per year/number of alcohol-related accidents per year) is estimated. The expected cost of an occasion of drunk driving is therefore $288. Hence, the total expected cost of an occasion of drunk driving is estimated as loss of statistical value of life plus other costs, which amounts to $373.

D. Effects on Social Security

The effect of heavy drinking on social security is pertinent from both the contribution and benefit aspects. Previous research has shown that alcohol consumption may influence earnings as well as life expectancy. Both earnings and life expectancy affects the revenue and payments of social security. Social security is a redistributive program, where benefit increases with, but is not, proportionate to contributions. The net effect of heavy drinking on social security is ambiguous — heavy drinking may reduce productivity, which reduces contributions to the social security fund. However, such a loss in contributions may be off-set by a reduction in the life expectancy among heavy drinkers. In another scenario, heavy drinking may not have as large of an impact as heavy drinkers have a shorter life expectancy and will not utilize as much social security. This counterbalances the loss in contributions due to the lack of productivity associated with heavy drinking. Hence, how heavy drinking affects social security is theoretically ambiguous.

Ostermann and Sloan (2004) investigate the effect of heavy drinking on the Old Age and Survivor Insurance Trust Fund (OASI), the largest component of the Social Security program. The main data source used is from the Health and Retirement Survey (HRS), which is merged with unique individual-level taxable earnings data from the Social Security Administration (SSA) and provides the Social Security taxable earnings history. There are three main findings from the study: 1) The lifetime contribution of heavy drinkers to the social security program is greater compared to the contribution of counterfactual light/moderate drinkers; 2) Heavy drinkers face reduced expected benefits compared to moderate drinkers; and 3) Greater contributions combined with lower benefits creates a net subsidy to the OASI by heavy drinkers. Eliminating heavy drinking would lead to a rise in the lifetime net expenditure (of the social security fund) among 25-year-old male and female heavy drinkers by $2,255 and $701, respectively. The authors conclude that there is no negative externality of heavy drinkers on OASI; if anything, heavy drinkers cross-subsidize others. I include the findings of Ostermann and Sloan (2004) to determine the cost of heavy drinking. Discounting the main findings of Ostermann and Sloan (2004) by using a discount rate of 3 percent to 18 year olds suggests that heavy drinkers subsidize social security by $1,201.75.

E. Taxes on Earnings and Productivity

To calculate the forgone taxes in income from loss of life expectancy due to heavy drinking, I use the survival probabilities estimated for heavy drinkers and non-drinking heavy drinkers. I combine the survival probabilities with the median income per age group obtained from the Census Bureau and marginal income tax rates extracted from the Current Population Survey of the U.S. Census Bureau and the NBER TAXSIM model. I estimate the lifetime contribution in terms of income taxes for heavy drinkers and non-heavy drinkers discounted to 18 years of age. The estimates suggest that a heavy drinker contributes $923 (in 2009 dollars) less in income taxes compared to a non-drinking heavy drinker over a lifetime.[10]

5. Summary

Table 9 sums up the estimates of the lifetime total costs associated with heavy drinking. Costs associated with specific events are discussed in the previous section. Lifetime Medicare taxes, weighted by age-specific median earnings and discounted to 18 years of age, are included in the section to attribute one's contribution to the state-provided healthcare system. The total

[10] To estimate the amount of income taxes forgone due to heavy drinking, I assume that both heavy drinkers and non-drinking heavy drinkers earn similar income.

number of drinks per lifetime is calculated by relying on the assumption that a heavy drinker consumes 3 drinks per day for 55 years starting from age 18. It has to be noted that this calculation assumes that a heavy drinker's life expectancy is 55 years at age 18 as portrayed in Table 5.1. The total alcohol taxes paid are then calculated by multiplying the total number of drinks per lifetime by the tax per drink in 2015 of $0.073 converted to 2009 dollars.

Table 9 shows that the external cost of heavy drinking per drink is $1.299 in column (1), which assumes that a heavy drinker consuming approximately 60,000 drinks in a lifetime will suffer from liver cirrhosis with a probability of 1 and have 15 major hospital visits related to the disease. Column (2) then reduces the number of hospital visits related to liver cirrhosis to 4 but still assumes that a heavy drinker will suffer from liver cirrhosis. Column (3) relaxes the probability of liver cirrhosis to 0.2 and assumes 4 hospital visits related to liver cirrhosis. Column (3), which uses the most conservative estimates among the three columns, estimates the external cost associated with drinking to be $0.464. The elasticity estimates shown in Table 2, along with the external costs (per drink) from Table 9, are entered into equation (4) to estimate the optimal tax rate per price of one drink. For the calculation, I use the 2011 price level ($1.34 per beer converted to 2009 dollars) and the elasticity estimates presented in Table 1 and 2 for 18 to 24 year olds.[11] The optimal tax per drink is estimated as 47.5 percent, 25.7 percent, and 17.15 percent of price per drink by using the estimates of columns (1), (2), and (3), respectively.

As drunk driving costs do not contribute much, reducing expected costs related to drunk driving does not change the estimate of optimal alcohol taxation. Figure 9 plots the optimal tax

[11] The elasticity estimates for 18 to 24 year olds are used because the costs related to heavy drinking have been discounted to 18 years of age. As shown in Tables 1 and 2, there is no statistical evidence suggesting that older age groups are sensitive to higher alcohol taxes, perhaps due to already established patterns of habit. From the BRFSS, heavy drinkers comprise 5 percent of drinkers.

estimates by allowing the probability of liver cirrhosis to vary, assuming that a person with liver cirrhosis makes 4 major hospital visits. The tax estimates range from 25.69 percent to 14.8 percent of price per drink with the probability of liver cirrhosis varying from 1 to 0. Years of life lost due to heavy drinking comprises a significant portion of the costs associated with heavy drinking. It is hard to accept that a heavy drinker will internalize the costs imposed to family members. For example, consider a simple scenario where a heavy drinker dies a premature death; say, due to liver cirrhosis. For a heavy drinker to internalize the costs imposed on family members, he/she would: 1) Have to be fully be aware of the risks associated with heavy drinking; and 2) Most importantly, a heavy drinker should be aware of the intensity of the burden he imposes on the family members in terms of emotional, financial, and other grounds.[12] Hence, in this study I explicitly treat costs imposed on family members as external.

6. Conclusion

Given the declining real alcohol taxes and price, mainly due to state and federal governments' reluctance to increase nominal alcohol taxes, this study estimates the optimal level of alcohol taxes in the United States. Drinkers now pay on average close to 7.5 cents per drink in tax. If alcohol taxes are to be used as a medium to allow heavy or risky drinkers to internalize the currently external costs associated with heavy drinking, alcohol taxes should address the externality imposed by heavy drinkers. Is the current level of alcohol taxes sufficient to cover the external costs associated with alcohol consumption?

[12] For example, a child who loses his father due to liver cirrhosis would have completely different outcomes in life if the father did not drink. To fully internalize the costs of heavy drinking, a heavy drinker should consider such costs when deciding to drink heavily.

I first estimate price elasticity among moderate and heavy drinkers by using recent state-level changes in beer taxes. The price elasticity estimation is followed by estimating the costs associated with heavy drinking in terms of years of life lost, medical expenses, drunk driving fatalities, and forgone income taxes due to the premature death of a heavy drinker. I borrow the established estimates of social security payments among heavy drinkers from Sloan and Ostermann's 2004 study. Finally, using the framework of optimal alcohol taxation by Pogue and Sgontz (1989), I estimate the optimal rate of alcohol taxes on the price per drink.

Heavy drinkers do not pay their way and the current level of alcohol taxes is insufficient to address the external costs related to alcohol consumption even after using conservative estimates for external costs. The differences in survival probability between heavy drinkers and non-drinking heavy drinkers start at 45 years of age. Heavy drinkers on average lose 3 years from their lives due to heavy drinking. The medical cost of heavy drinking is imposed mainly on private insurance, Medicaid, and Medicare; and the substitution into Medicare is well evident after the age of 65. Assuming that heavy drinkers and non-drinking heavy drinkers earn a similar income, heavy drinkers pay approximately $900 less income taxes in a lifetime. Estimates after adjusting for the probability of alcohol-related disease suggest that the optimal tax is 17.5 percent of the price per drink. It has to be emphasized that the calculation to obtain such an estimate uses conservative values and represents an estimate towards a lower range.

Disclosure

The authors have no financial arrangements that might give rise to conflicts of interest with respect to the research reported in this paper.

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Figure 1

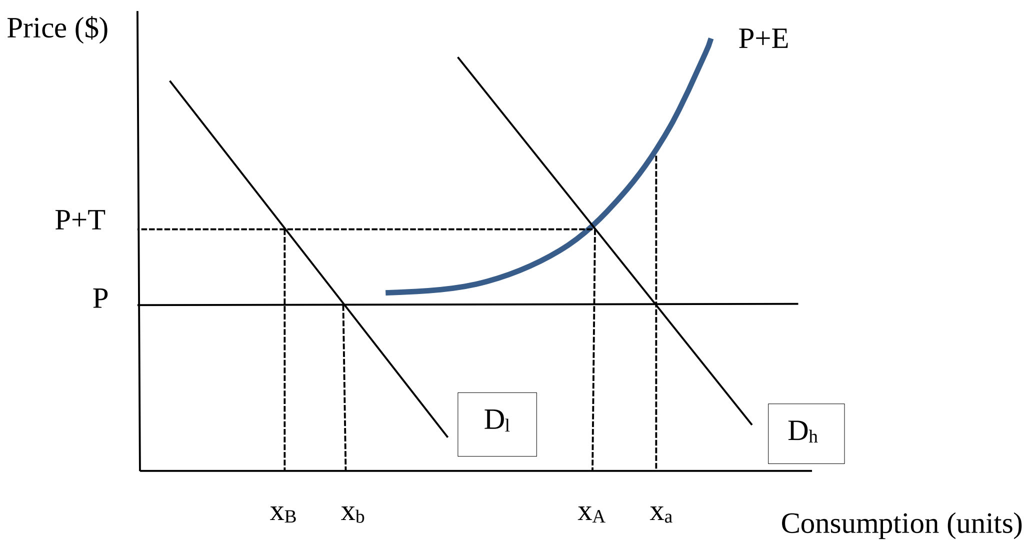


Figure 2A

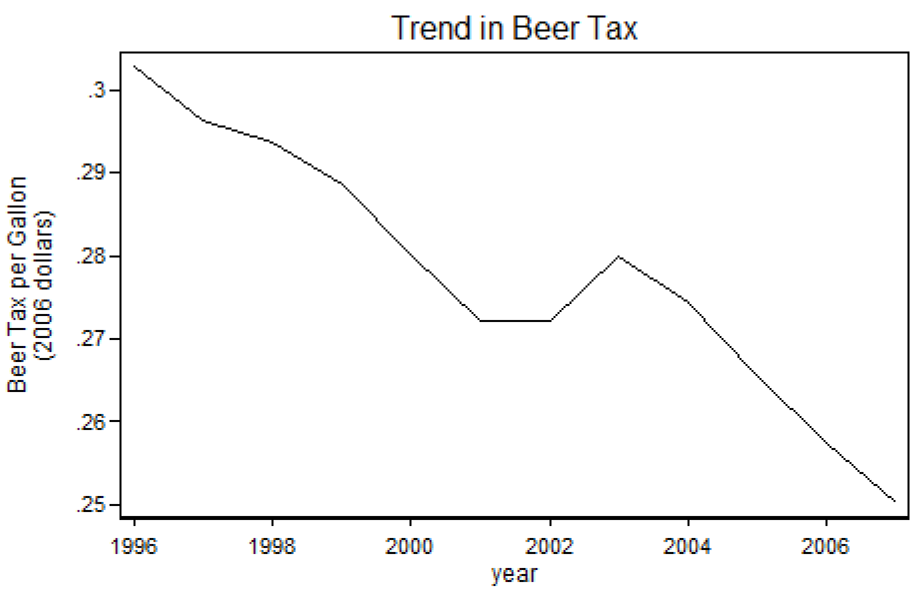


Figure 2B

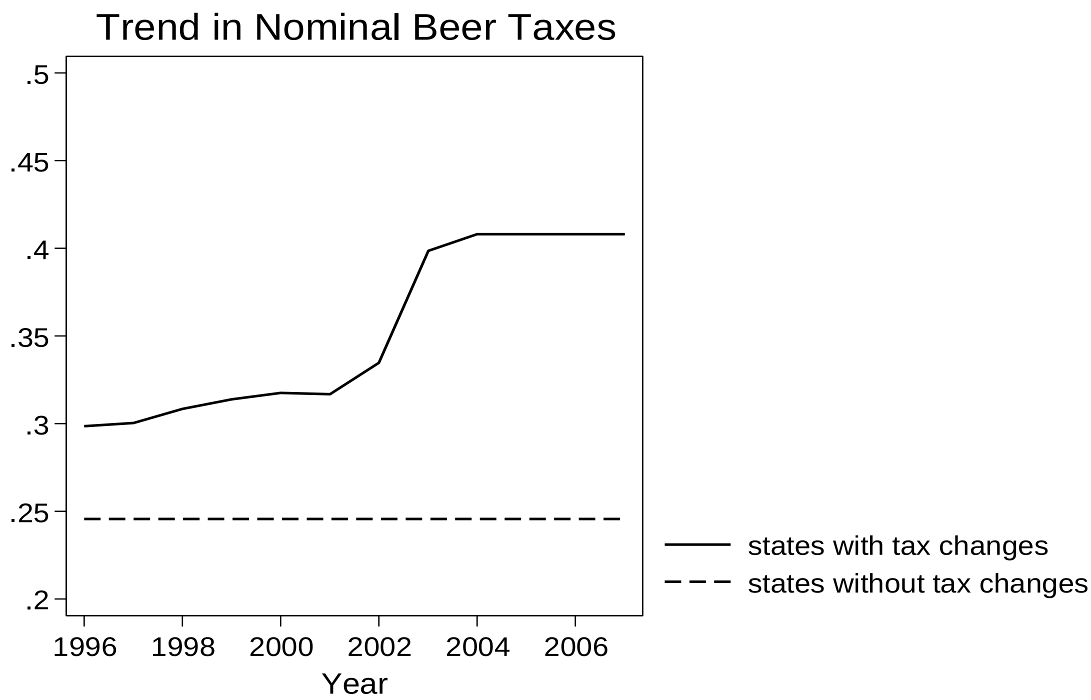
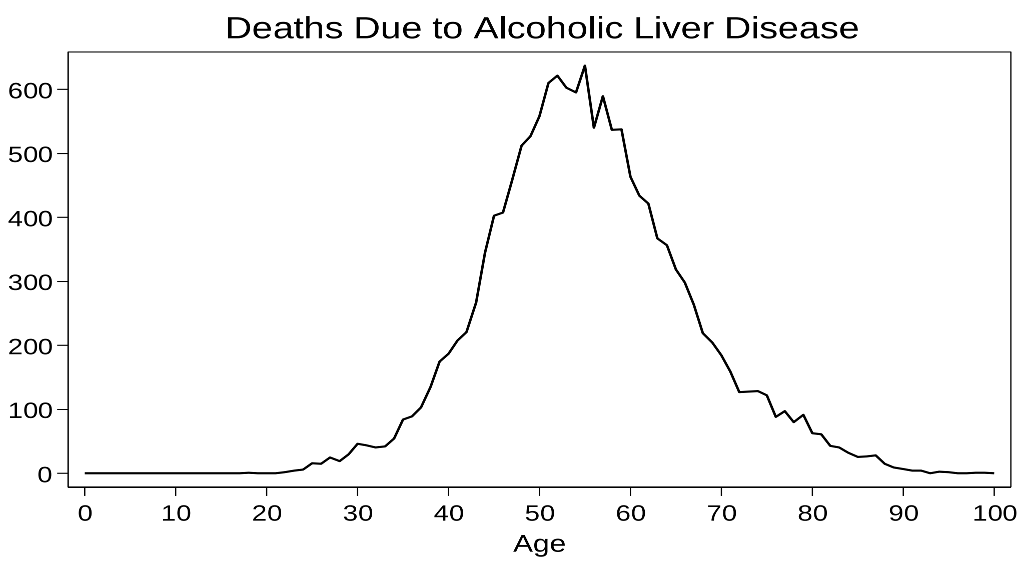


Figure 3



Note: Data Source NCHS (2009)

Figure 4

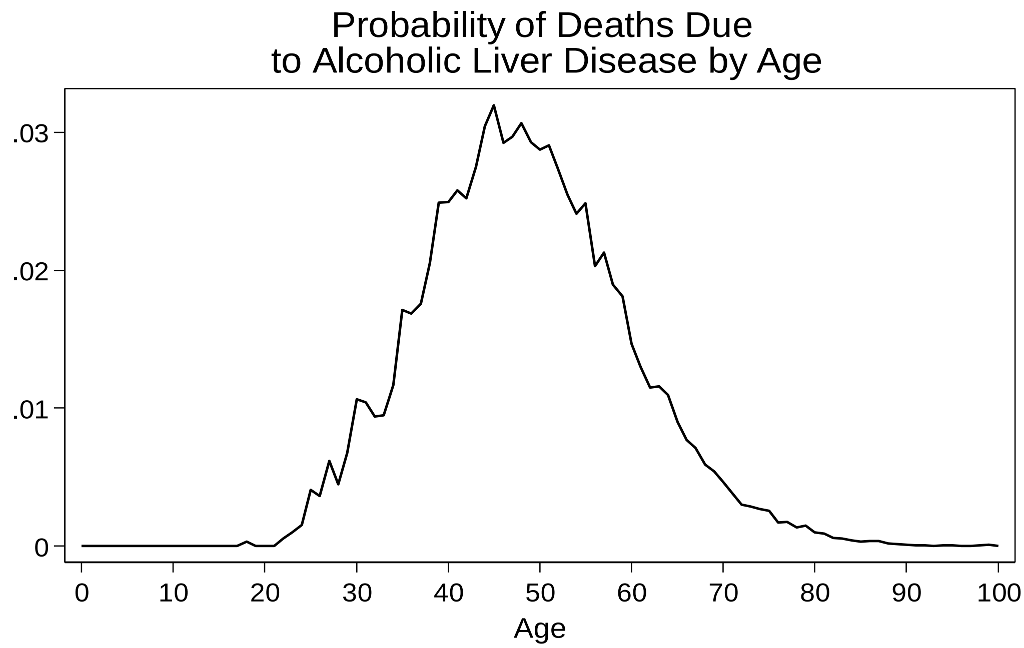


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Figure 5

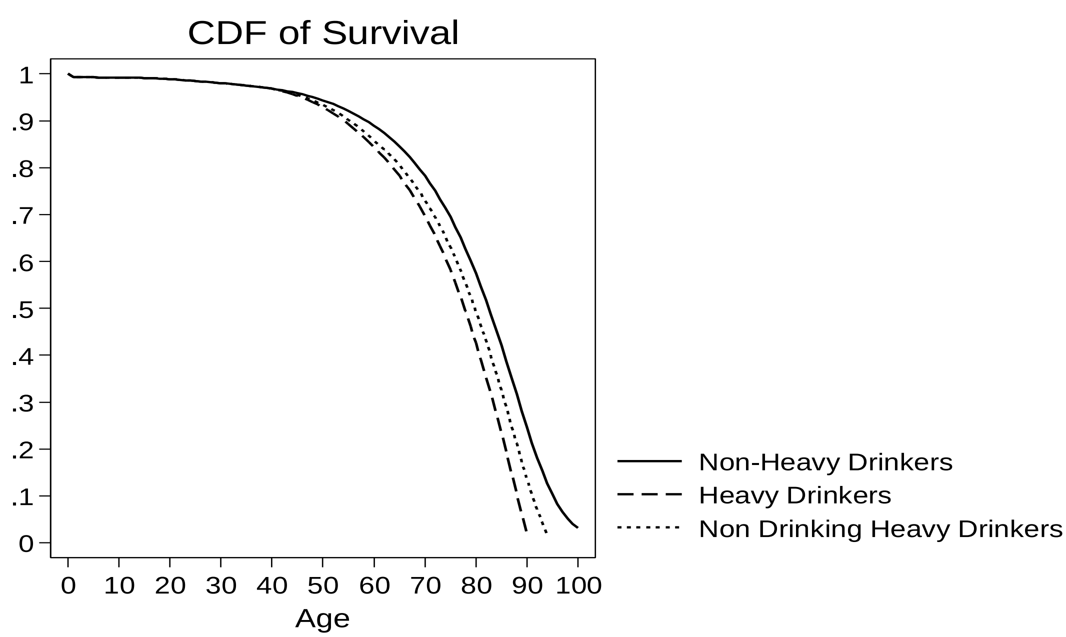

Figure 6

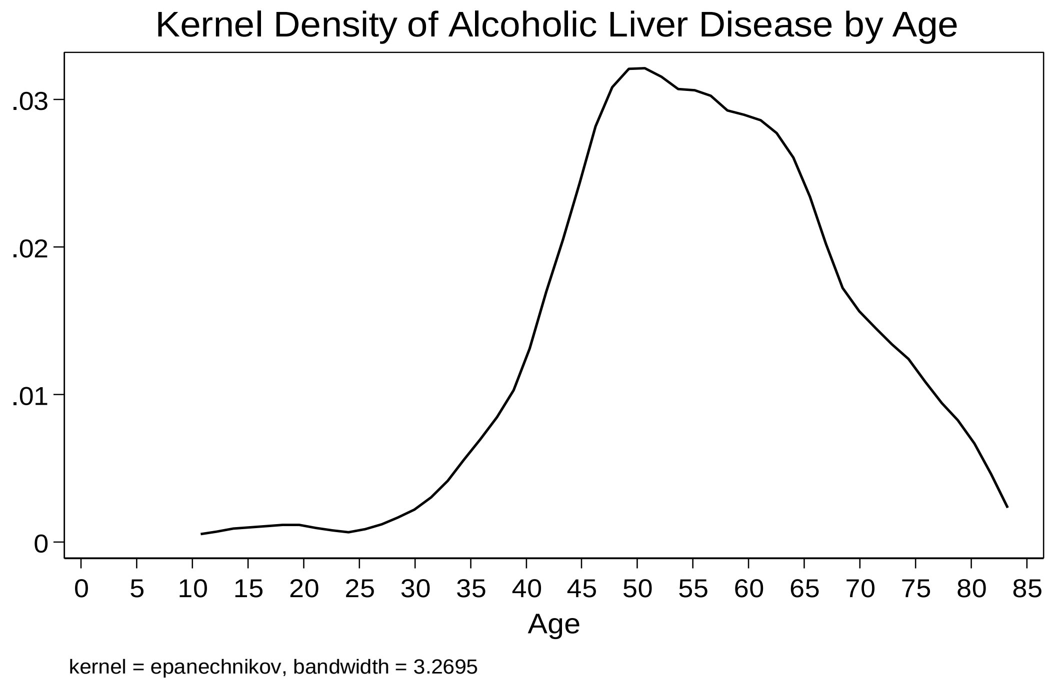

Figure 7

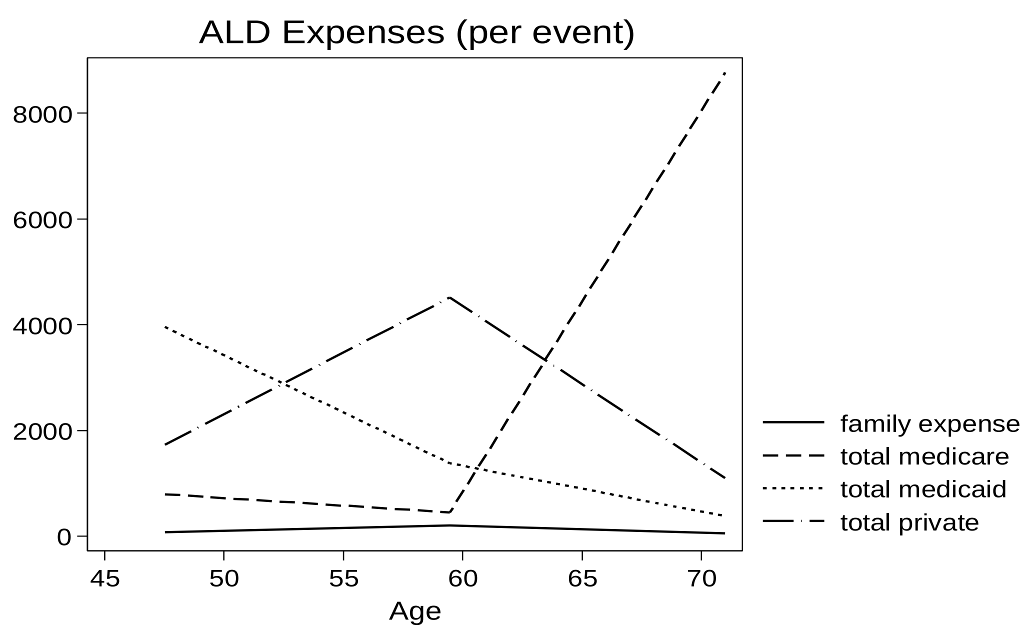

Figure 8

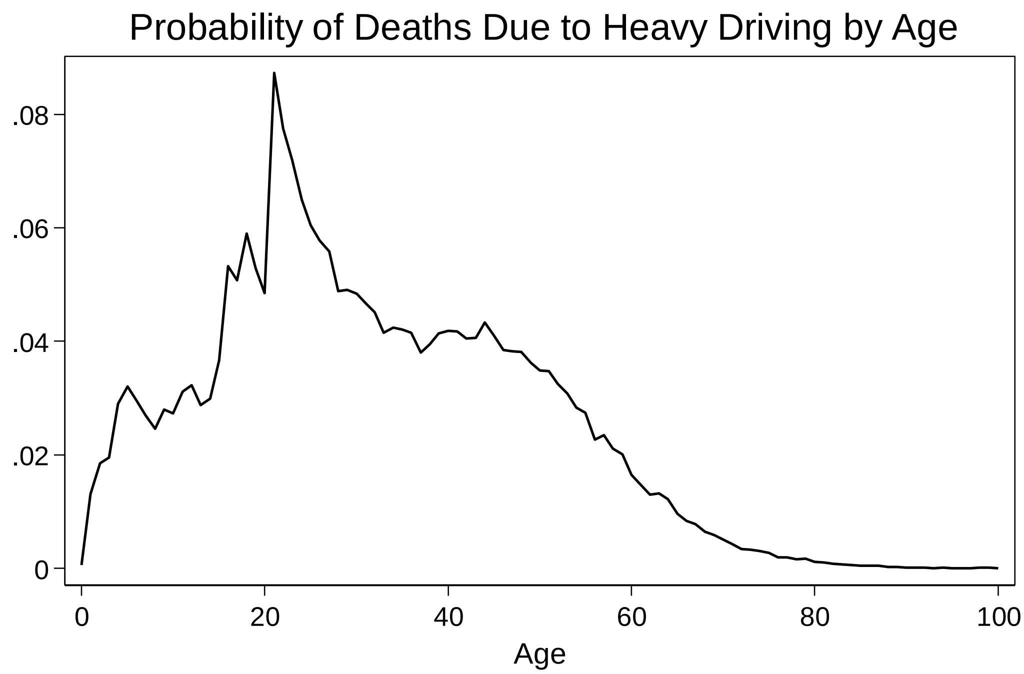

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Figure 9

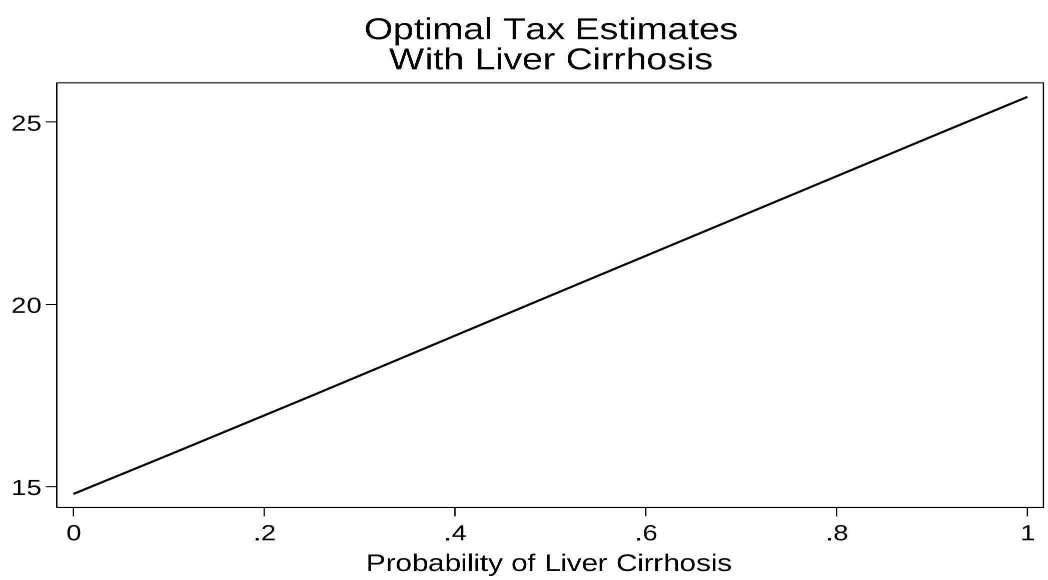

Table 1. Descriptive Statistics from the BRFSS (age 18-24 year olds)

Variable	Mean	Std. Dev.
Current drinker	0.556	0.497
Drinks per month	15.055	41.333
Log of drinks per month	2.388	1.374
Real state-level beer tax (per gallon)	0.293	0.254
Real cigarette tax	3.660	0.855
Liquor outlet (per capita)	1.201	0.622
Percent dry	3.038	8.905
Bandummy	0.087	0.282
BAC 0.08 percent	0.722	0.448
Zero tolerance law	0.982	0.134
Sunday sales ban	0.301	0.459
Keg deposit required	2.232	10.163
Information required	0.418	0.493
Age	21.252	2.028
White	0.751	0.432
Black	0.116	0.320
Other race	0.133	0.339
Married	0.200	0.400
Divorced	0.016	0.127
Unmarried couple	0.085	0.279
Other marital status	0.698	0.459
Less than high school	0.134	0.341
High school	0.371	0.483
College	0.494	0.500
Education missing/refused	0.001	0.032
Employed	0.559	0.496
Self employed	0.038	0.191
Out of work	0.085	0.278
Student	0.238	0.426
Other employment status	0.080	0.271
Income <$10,000	0.082	0.274
10,000>=Income<15,000	0.066	0.248
15,000>=Income<20,000	0.103	0.304
20,000>=Income<25,000	0.124	0.329
25,000>=Income<35,000	0.146	0.353
35,000>=Income<50,000	0.125	0.330
Income>=50,000	0.163	0.369
Income (not sure)	0.163	0.369
Income refused	0.029	0.167

Gender (male = 1)	0.427	0.495

N = 147,630 for all the variables except N = 80,213 for log of number of drinks.

Table 2. Effect of Higher Taxes on Alcohol Consumption

	drinking participation	OLS	25th quantile	50th quantile	75th quantile
Log (real beer tax)	-0.045***	-0.038	0.024	-0.004	-0.125***
	0.076	0.048	0.075	0.057	0.054
Liquor outlets (per capita)	-0.002	0.029	0.041	0.018	0.004
	0.046	0.022	0.034	0.026	0.025
Percent dry	0.002	-0.015*	-0.018*	-0.021*	-0.002
	0.011	0.009	0.011	0.011	0.014
Real cigarette price	-0.003	0.030	0.015	0.052**	0.053**
	0.033	0.019	0.027	0.025	0.024
R-square	0.111	0.131	0.063	0.082	0.084
N	147,626	81,869	81,869	81,869	81,869

Note: The first-part model is estimated by using a logistic regression. The second part model uses log of drinks consumed per month as the dependent variable. All specifications include controls for the proportion of states' population affected by smoking ban in bars, anti-smoking sentiment constructed by using DeCicca et al.'s method, BAC of 0.08 percent, Sunday sales ban, zero tolerance policy, keg deposit required, age, age square, race, marital status, education, employment, income, gender, quarter dummies, year fixed effects, and state fixed effects. * represents $p<0.10$, ** represents $p<0.05$, and *** represents $p<0.01$

Table 3. Division of Costs		
	Internal	External
Premature death		Drinker and Family
Pain and Suffering	Drinker and Family	Drinker and Family
Medical Costs	Copay	Insurance reimbursement
Sick Leave	Uncovered sick loss	Covered sick loss
Disability	Forgone Income not replaced	Disability benefit
Pension	Defined -contribution plans	Social security and defined benefits
Wages	Forgone disposable income	Taxes on earnings/productivity
Other Costs	Motor vehicle damages to oneself	Motor vehicle damages to innocent party
Alcohol products	Purchases	

Table 4. Summary Statistics of Heavy and Moderate Drinkers

	Heavy Drinkers (N=322, except N=108 for mortality age)		Non-Heavy Drinkers (N=28556, except N=5904 for mortality age)	
Variables	Mean	Std. Dev.	Mean	Std. Dev.
mortality age	65.028	13.849	75.539	14.398
smoker	0.525	0.500	0.251	0.434
former smoker	0.217	0.413	0.241	0.427
non-smoker	0.252	0.435	0.498	0.500
smoking status unknown	0.006	0.079	0.010	0.100
sex (male=1)	0.767	0.423	0.413	0.492
white	0.845	0.363	0.823	0.382
black	0.124	0.330	0.139	0.346
other	0.031	0.174	0.039	0.193
less than high school	0.189	0.392	0.221	0.415
high school	0.410	0.493	0.377	0.485
college	0.335	0.473	0.315	0.464
more than college	0.065	0.247	0.085	0.279
education unknown	0.000	0.000	0.003	0.053
income<5,000	0.043	0.204	0.057	0.231
income (5,000-6,999)	0.050	0.218	0.039	0.193
income (7,000-9,999)	0.062	0.242	0.055	0.228
income (10,000-14,999)	0.090	0.287	0.094	0.291
income (15,000-19,999)	0.090	0.287	0.095	0.293
income (20,000-24,999)	0.075	0.263	0.082	0.275
income (25,000-34,999)	0.155	0.363	0.140	0.347
income (35,000-49,999)	0.177	0.382	0.143	0.350
income>=50,000	0.174	0.380	0.157	0.364
income unreported	0.084	0.278	0.138	0.345
body mass index (bmi)	25.935	8.914	26.325	14.871
bmi square	751.826	1515.014	914.140	9105.082
20-29 year olds	0.196	0.397	0.230	0.421
30-39 year olds	0.286	0.452	0.236	0.425
40-49 year olds	0.186	0.390	0.164	0.370
50-59 year olds	0.118	0.323	0.114	0.318
60-69 year olds	0.134	0.341	0.121	0.326
70-79 year olds	0.062	0.242	0.093	0.290
80-89 year olds	0.019	0.135	0.039	0.193
90-100 year olds	0.000	0.000	0.003	0.057

Note: The data source is the linked version of NHIS (1990) with NVSS (1990-2004) multiple causes of death. Heavy drinkers are defined by individuals consuming more than 3 drinks per day in the 1990 survey.

Table 5.1 Life Expectancy at Age 18

	Non-Heavy Drinker	Non-Drinking Heavy Drinker	Heavy Drinker	Effect of Heavy Drinking
Life Expectancy	61.56	58.54	55.48	-3

Note: Life expectancy for non-heavy drinkers, non-drinking heavy drinkers, and heavy drinkers at the age of 18 is estimated by summing a person's years lived at and above age 18 and dividing the sum by the number of people alive at 0 years (100,000). The life expectancy of heavy drinkers is then compared with non-drinking heavy drinkers to calculate the loss in years lived attributed to heavy drinking. The calculation excludes deaths from alcohol-related accidents.

Table 5.2 Value of Life-Years Lost

Value of Life Years Lost	$57,552

Note: Value of life-years lost is calculated by using a value of $100,000 per life-year lost multiplied by expected years of life lost attributed to heavy drinking. It is discounted at 3 percent per year to age 0.

Table 6. Descriptive Statistics from MEPS (2000 to 2012)

	Liver Cirrhosis (N=374)		No Liver Cirrhosis (N=283267)	
	Mean	Std.Dev.	Mean	Std.Dev.
family expenses	173.075	1037.057	209.456	1689.281
Medicare expenses	3466.745	10345.060	1622.476	6154.943
Medicaid expenses	4501.054	23750.950	412.533	3275.852
private insurance expenses	4237.861	16306.790	1976.037	8455.277
ER expenses	489.992	1397.448	343.407	1231.975
total expenses	13138.950	29001.590	4856.713	12043.07
log(Medicare expenses)	7.719	2.344	5.913	2.085
log(Medicaid expenses)	7.339	2.358	6.945	2.174
log(private insurance expenses)	7.485	2.041	6.396	2.014
log(ER expenses)	5.966	1.345	5.738	1.274
log(family expenses)	4.462	1.673	4.413	1.746
age	55.413	14.327	47.318	23.088
sex	0.531	0.500	0.422	0.494
white	0.821	0.384	0.706	0.456
black	0.102	0.303	0.106	0.307
others	0.077	0.267	0.189	0.391
refused	0.042	0.202	0.119	0.324
married	0.485	0.500	0.471	0.499
divorced, separated, widowed	0.320	0.467	0.242	0.428
never married	0.153	0.361	0.168	0.374
less than 5th grade	0.145	0.353	0.218	0.413
5th grade to high school	0.510	0.501	0.414	0.493
high school	0.111	0.314	0.145	0.352
some college	0.235	0.424	0.221	0.415
retire inapplicable	0.491	0.501	0.611	0.488
retired	0.253	0.435	0.205	0.403
not retired	0.256	0.437	0.184	0.388
smoking inapplicable	0.173	0.379	0.156	0.363
smoker	0.183	0.388	0.125	0.331
non smoker	0.441	0.497	0.500	0.500
smoke missing	0.202	0.402	0.219	0.414
inapplicable, refused	0.779	0.415	0.588	0.492
management, business	0.064	0.245	0.063	0.243
professional and related	0.038	0.191	0.091	0.287
service industry	0.014	0.119	0.069	0.253
sales and related	0.027	0.161	0.046	0.208
office and administrative	0.038	0.192	0.060	0.238

farming, construction, production, transportation	0.040	0.196	0.084	0.277
survey year 2000	0.012	0.110	0.067	0.251
survey year 2001	0.025	0.157	0.081	0.273
survey year 2002	0.054	0.226	0.093	0.291
survey year 2003	0.116	0.321	0.079	0.270
survey year 2004	0.112	0.316	0.084	0.277
survey year 2005	0.105	0.307	0.079	0.269
survey year 2006	0.113	0.317	0.075	0.264
survey year 2007	0.073	0.261	0.072	0.258
survey year 2008	0.135	0.343	0.075	0.263
survey year 2009	0.052	0.222	0.076	0.265
survey year 2010	0.107	0.310	0.075	0.263
survey year 2011	0.046	0.211	0.075	0.263
survey year 2012	0.048	0.215	0.070	0.254
region unreported	0.002	0.039	0.008	0.089
Northeast	0.201	0.401	0.219	0.414
Midwest	0.328	0.470	0.270	0.444
South	0.282	0.450	0.325	0.468
West	0.188	0.391	0.178	0.382

Table 7.1. Breakdown of Payments by Various Sources

	Out of pocket	Medicare	Medicaid	Private Insurance	Other Federal	Other State
In-patient Expenses	5,274,562	65,442,404	220,888,104	123,300,859	4,551,583	636,870
Outpatient Expenses	1,859,784	4,210,120	920,181	21,111,421	0	6,122
Total Expenses by Source Type	7,134,346	69,652,524	221,808,285	144,412,280	4,551,583	642,992

Note: The estimates are calculated using the mean values of respective expenses and multiplying the estimates by 30,627 cases of deaths due to liver cirrhosis in 2009 as identified in the National Vital Statistics of the NCHS. The numbers above are annual estimates of respective expenses by payer's type. All expenses are reported in 2009 dollars.

Table 7.2. Cost of Health Services Attributable to Liver Cirrhosis by Payer per Event (2009 dollars)

	Out of pocket	Medicare	Medicaid	Private Insurance	Other Federal	Other State
In-patient Expense	33.198	471.568	2252.096	1232.515	49.783	0.000
Outpatient Expenses	20.341	34.253	10.064	230.831	0.000	0.067
Total Expenses by Source Type	53.539	505.821	2262.161	1463.345	49.783	0.067

Note: According to the NCHS, the majority of deaths related to ALD occur between 50 and 60 years of age. I use 55, the mean age of death due to liver cirrhosis (except when calculating the values of Medicare payments, when age 65 is used) and discount the values of total in-patient and outpatient expenses to 18 years old. All expenses are reported in 2009 dollars.

Table 7.3. Liver Cirrhosis Expenses per Event

	Out of pocket	Medicare	Medicaid	Private Insurance
Total Expenses	90.22	1663.72	1930.24	1954.51

Note: The expenses are adjusted by age-specific survival probabilities and are discounted to 18 years of age using a discount rate of 3 percent. All expenses are reported in 2009 dollars. It is uncertain as to how many times a patient with liver cirrhosis visits a hospital. Total expenses related to liver cirrhosis can be obtained by multiplying above numbers by 15, which is the assigned number of times a patient visits the hospital in a life time. Total numbers of visits are allowed to vary from 10 to 20 times.

Table 8. Effect of Heavy Drinking on Forgone Income Taxes

Age Group	Median Income	Survival probability heavy drinkers	non drinking heavy drinkers	Marginal Rate Tax	Expected Tax (HD)	Expected Tax (NHD)	Difference	discounted to 18
15-24 year old	10,323	0.986	0.986	0.185	18,837.823	18,837.823	0.000	0.000
25 to 34	31,201	0.980	0.980	0.247	75,550.680	75,550.680	0.000	0.000
35 to 44	38,461	0.969	0.969	0.268	99,834.364	99,834.364	0.000	0.000
45 to 54	38,979	0.929	0.934	0.274	99,181.784	99,765.748	-583.964	-226.775
55 to 64	34,512	0.843	0.858	0.271	78848.235	80240.262	-1392.026	-402.239
64 and up	20,816	0.697	0.731	0.237	34,384.065	36,055.217	-1671.152	-359.319
						Total Difference		-988.333

Note: The median income for specific age groups is extracted from the Census Bureau and represented in 2012 dollars. Age-specific survival probabilities estimated for both heavy drinkers and non-drinking heavy drinkers are used. Then marginal rate of tax for each age group is based on the Current Population Survey of the U.S. Census for March 1996 and the NBER TAXSIM model. The forgone tax amount is discounted to age 18 by using a discount rate of 3 percent. The difference in lifetime tax amount of $988.33 is converted to 2009 dollars using the Consumer Price Index.

Table 9. Taxes, Cost, and Contribution by a Heavy Drinker

	cost and contribution		
	(1)	(2)	(3)
Costs			
Years of Life Lost	-57,552	-57,552	-57,552
Medicare and Medicaid	-53909.4	-17965	-3593
Drunk driving	-373	-373	-373
Effects on Social Security	1201.75	1201.75	1201.75
Forgone Income Taxes	-923	-923	-923
Contribution			
*Lifetime Medicare Taxes**	*28,910*	*28,910*	*28,910*
total number of drinks	60225	60225	60225
total tax paid	4396.425	4396.425	4396.425
Number of Visits	15	4	4
Probability of Liver Cirrhosis	1	1	0.2
Total External cost of Heavy Drinking	-78,249	-42,305	-27,933
Total External Cost of Heavy Drinking per Drink	-$1.299	-$0.702	-$0.464

Note: Column (1) shows the calculation assuming that a patient suffering from liver cirrhosis has 15 major events that lead to a hospital stay and a heavy drinker has a probability of liver cirrhosis of 1. Column (2) reduces the number of major hospital visits to 4. Column (3) jeeps the number of major hospital visits to 4, but assumes a probability of 0.2 for liver cirrhosis. Although reducing the number of visits reduces the external cost associated with heavy drinking, the total external cost of heavy drinking is still positive.