Understanding the Demand for Alcohol in the United States

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An abstract of a
Dissertation submitted to the Faculty of the
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Abstract

This dissertation consists of three chapters which are dedicated in understanding the demand for alcohol in the United States. Chapter 1 investigates whether heavy drinkers among young adults are more responsive to higher alcohol prices compared to light or moderate drinkers. I find that the price elasticity of demand is highest among heavy drinkers. Chapter 2 studies the relationship between cigarettes and alcohol by investigating the effect of higher cigarette prices on alcohol consumption among young adults, exploiting sizeable variation in cigarette prices after the Master Settlement Agreement. I find that young adults increase their alcohol consumption in response to higher cigarette prices suggesting that cigarettes and alcohol are substitutes. The pattern of substitution is prevalent across the light, moderate, and heavy drinkers; however, substitution is more concentrated towards heavy drinkers. Chapter 3 improves the understanding of the optimal level of alcohol taxation in the United States by considering the external cost associated with heavy drinking. I conclude that the optimal tax rate is 14 percent of price per drink. Even the conservative estimates suggest that heavy drinkers do not pay their way out.

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Preface

Chapter 1

Estimating the Price Elasticity of Demand for Different Levels of Alcohol Consumption among Young Adults

In this study, I estimate the differential responses to alcohol prices on alcohol demand for young adults by asking whether heavy drinkers are more responsive to higher alcohol prices than light and moderate drinkers. Understanding the demand for higher alcohol prices on one's level of alcohol consumption is crucial when evaluating the effectiveness of using alcohol taxes as an alcohol control medium. From a policy perspective, heavy drinkers should reduce their alcohol consumption in response to increases in alcohol consumption for taxes to be effectively used as a medium to reduce alcohol-related negative externalities.

Whether heavy drinkers among young adults respond to higher alcohol prices remains a topic which has surprisingly caught little attention. Two studies directly analyze the differential effects of higher alcohol prices on alcohol consumption. Manning et al. (1995) uses data from the 1983 National Health Interview Survey (NHIS) and implement the quantile regression method to investigate the effect of higher alcohol prices on different levels of alcohol consumption. The authors find that moderate drinkers are much more price elastic compared to light or heavy drinkers. Aayagari et al. (2013) implements finite mixture model and uses data from the Health and Retirement Survey (HRS). The authors find that higher alcohol prices lower alcohol consumption for light drinkers among older adults but do not affect the group that is comprised of heavy drinkers.

In this chapter I use the data from the National Longitudinal Survey of Youth (NLSY97) from 1997 to 2008 to estimate the differential effects of higher alcohol prices on alcohol demand among young adults. I use three different econometric techniques. First, I use the quantile regression to analyze the differential effects of higher alcohol prices on alcohol consumption. The quantile regression method allows the effect of higher alcohol prices to vary across the conditional quantiles. I follow the analysis by implementing a penalized quantile regression approach which is helpful in controlling for the unobserved heterogeneity across individuals. Lastly, I use a finite mixture model to investigate the heterogeneous effects of higher alcohol prices on alcohol demand. The finite mixture model postulates that the draws are extracted from subpopulations within a population which cannot be possibly identified by breaking the sample down according to age, gender, or level of alcohol consumption (Ayyagari et al. 2013).

This paper has three main findings. From the pooled quantile regression method, I find that price effects are negative and statistically significant for relatively heavy drinkers. The price elasticities are -0.304 and -0.27 at 75^{th} and 90^{th} respective quantiles for current drinkers. Similarly, results from quantile regression for the panel data suggest that the price effects are concentrated at the higher end of the conditional distribution with the elasticity magnitude of -0.304 and -0.439 at the 75^{th} and 90^{th} respective quantiles. These results are in sharp contrast to the findings of Manning et al. (1995), which suggest that heavy drinkers are unresponsive to higher alcohol prices. Finally, using the finite mixture model, I discover two latent groups — one responsive to increases in alcohol prices and the other unresponsive. The findings suggest that the group responsive to higher alcohol prices is likely to be comprised of those who drink relatively more alcohol. The price elasticity associated to the responsive group is -0.428. The results further indicate that individuals prone to violence, drunk driving, and binge drinking are likely to fall under the group that is responsive to higher alcohol prices.

To provide direct comparison across previous studies investigating the price elasticity of demand for alcohol is difficult due to the differences in regression framework (such as differing functional form, choice of method, and the use of independent and dependent variables) and timeframe of the sample. Overall, my estimates of price elasticity (estimated at the conditional means) compared to the existing findings from the NLSY data is modest. My elasticity estimates obtained by the OLS for current drinkers of -0.209 (Table 3) and -0.27 (Table 4) are close to the price elasticity of -0.20, which was found by Nelson (2014) after conducting a meta-analysis of 191 estimates obtained from 114 primary studies.[1]

There exists an extensive literature that focuses on the reduced form estimation of higher alcohol prices and taxes on the consequences of heavy drinking, such as liver cirrhosis, alcohol-related traffic fatalities, and crime (Cook and Tauchen (1982), Grossman (1993), Sloan et al. (1994), Saffer and Grossman (1987), Chaloupka et al. (1993), Ruhm (1996), Cook and Moore (1993), Sloan et al. (1994), Markowitz and Grossman (1998, 2000), Markowitz (2000)). The findings from these studies indicate that increases in alcohol prices are an effective means in reducing cases of liver cirrhosis, traffic fatalities, alcohol related deaths and violence. The results from this study, which suggests that young adults who are relatively heavy drinkers respond to higher alcohol prices by reducing their alcohol consumption, supports such previous findings in the literature.

The overall result supports the use of alcohol taxation as a revenue-increasing medium as it is an inelastic product (at least for the young adults' spectrum). While there is a growing concern regarding the issue of alcohol taxation at a political level, this study provides new findings that emphasize the possibility of higher alcohol taxes in reducing alcohol consumption among heavy drinkers.

Chapter 2

Do Young Adults Substitute Alcohol for Cigarettes? Learning from the Master Settlement Agreement

The second chapter examines the relationship between cigarettes and alcohol. Considering the relationship between cigarettes and alcohol has been largely ignored in the field of health economics. It is important to identify the relationship between cigarettes and alcohol from a policy perspective. For example, if these two substances are unrelated, then a policy can

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[1] While obtaining the meta-analysis, Nelson (2014) addresses the issue of biases occurring due to differences in sampling and publication bias

be used to address the demand for alcohol and cigarettes independently. This is what the policy makers often do. However, if cigarettes and alcohol are substitutes then a policy aimed at one substance should consider the interdependence nature of cigarettes and alcohol. Otherwise, a policy implemented to solve one particular problem might create a new one.

Whether cigarettes and alcohol are complements or substitutes remains an open question. Only handful of studies in economics has examined the relationship between cigarettes and alcohol among young adults. These studies have produced ambiguous results; some suggesting that cigarettes and alcohol are complements (Dee, 1999; Chaloupka et al., 1999; and Williams et al., 2004) and others claiming that they are substitutes (Decker and Swartz, 2000; Picone et al., 2004; Pacula, 1998; and Markowitz and Tauras, 2009). From a biological and physiological perspective cigarettes and alcohol can be complements. However, fundamental economic theory suggest that increases in cigarette prices may influence an individual to substitute cigarettes for alcohol, as alcohol is now relatively cheaper compared to cigarettes (holding alcohol prices constant). Hence, determining whether cigarettes and alcohol are substitutes or complements is an empirical problem.

This study is specifically relevant to current situation because of how the policy measures have been disproportionately deployed. For instance, nominal levels of alcohol taxes have not risen since 1991 and the real alcohol prices and taxes have failed to keep par with inflation. In contrast, real cigarette prices and taxes have been increasing rather dramatically over the past two decades, especially after the Master Settlement Agreement in 1998. These are two contradicting policies. The broader question is should we be concerned about such contrast in policies.

This study explores the relationship between cigarettes and alcohol. I evaluate the effect of higher cigarette prices before and after the Master Settlement Agreement (1998) on alcohol demand among 18-to-24 year olds by analyzing the cross-sectional data from the Behavioral Risk Factor Surveillance System (BRFSS) from 1990 to 2008. Specifically, I examine whether sizable increases in cigarette prices changed or altered the relationship between cigarettes and alcohol.

Second purpose of this study is to examine the heterogeneous effects of higher cigarette prices on the levels of alcohol consumption. In other words, I ask whether higher cigarette prices affected light, moderate, and heavy drinkers in a similar manner. Although focusing on the mean impact is important while highlighting the link between cigarettes and alcohol, relying on such estimates might mask potential heterogeneity in alcohol consumption. The concern of heterogeneity is of special interest in the case of alcohol consumption as prior research provide suggestive evidence that low levels of alcohol consumption is beneficial to one's health (Dyer et al., 1980; Klatsky et al., 1981; and Marmot et al., 1981). In contrast, the majority of health risks and externalities associated with alcohol consumption arise from those who misuse alcohol (Grossman et al., 1994; Markowitz, 2000; DeSimone, 2007). From a viewpoint of minimizing alcohol-related externalities, it is problematic if heavy drinkers are substituting cigarettes for alcohol.

This study has four main findings. First by using the regression discontinuity design I find that MSA increased alcohol consumption among young adults. Subsequently, I find that sizable increases in cigarette prices after the Master Settlement Agreement changed or altered the link between cigarettes and alcohol. In the pre MSA period, the findings provide no relationship between cigarettes and alcohol. In contrast, in the post MSA period higher cigarette prices led young adults to increase their level of alcohol consumption suggesting a pattern of substitution. Second, using a quantile regression method, I find that the pattern of substitution is prevalent across the conditional distribution of alcohol consumption. In other words, light, moderate, and heavy drinkers increased their alcohol consumption as a response to higher cigarette prices. However, the level of substitution is concentrated among heavy drinkers. Furthermore, using a finite mixture model, I find that binge drinkers are more likely to increase their alcohol consumption due to higher cigarette prices. With an intuition that if heavy drinkers are increasing their alcohol consumption in response to higher cigarette prices the effect may be evident on forms of alcohol-related externalities, I examine the effect of higher cigarette prices on drunk driving fatalities. I find that increases in cigarette prices in the years following the MSA are positively associated with drunk driving fatalities.

This study informs policymakers by highlighting the unintended effects of higher cigarette prices, indicating that policymakers should consider the interdependence nature between cigarettes and alcohol while using increases in cigarette taxes as a medium to discourage smoking or raise tax revenues.

Chapter 3

How “Efficient” are the Current U.S. Alcohol Taxes?

The final chapter of my dissertation improves the understanding of efficient level of alcohol taxation here in the U.S. by accounting for external costs associated with heavy drinking. According to the National Vital Statistics System’s (NVSS) multiple death cases in 2009, approximately 22,000 deaths in the U.S. can explicitly be contributed to heavy drinking. Although, marginal external cost of alcohol consumption is negligible among light drinkers, marginal external cost increases for heavy drinkers. For instance, a heavy drinker, who decides to drive after drinking profusely, fails to internalize the social costs associated with heavy drinking. In a Pigovian concept, alcohol taxes should cover the external costs associated with alcohol consumption to avoid market failures.

Two previous studies estimate the optimal taxes on alcohol. Seminal work of Pogue and Sgontz (1989) sets up a framework to obtain the optimal level of alcohol taxation. The authors then empirically estimate optimal level of alcohol taxation, presenting a wide estimate of alcohol taxes ranging from 19 to 306 percent. Kenkel (1996) extends the framework of Pogue and Sgontz and finds that optimal tax rate is over 100 percent of the net-of-tax price. However, the author emphasizes alcohol taxation as a second best option concluding that alcohol taxation would be much lower if severe penalties were inflicted among cases of drunk driving. Due to the lack of differential estimates of price elasticity among light and heavy drinkers, Pogue and Sgontz’s study explicitly assumes that the price elasticity of demand for both drinkers is equal. Both the studies can be improved in terms of estimating the external costs associated with alcohol consumption. Kenkel's study borrows the measure of cost from Manning et al.'s study, conducted in 1989 which uses the data of year 1983. The absence of initiative shown by the policy makers to raise alcohol taxes motivates to question the efficiency of U.S. alcohol taxes or the lack of it.

If light drinkers have higher price elasticity of demand compared to heavy drinkers, increases in alcohol taxes is likely to create a deadweight loss which outweighs the increase in social welfare due to potential reduction in alcohol-related externalities. However, my study provides evidence that heavy drinkers of 18-24 year olds have the largest price elasticity of demand. I then estimate the external cost associated with heavy drinkers in forms of: 1) Years of life lost, 2) Social insurance system, 3) Drunk driving accidents, and 4) Forgone income taxes. I find that heavy drinkers do not pay their way. An estimate from the benchmark model suggests that an optimal level of alcohol tax rate is 39 percent of price per drink. After making adjustment to the probability of alcohol related diseases, I conclude that the optimal tax rate is 14 percent of price per drink. Even the conservative estimates suggest that current alcohol taxes address only 5 percent of the external costs related to alcohol consumption.

Chapter 1

Estimating the Price Elasticity of Demand for Different Levels of Alcohol Consumption among Young Adults

Abstract

Understanding the effect of higher alcohol prices on alcohol demand according to one's level of alcohol consumption is crucial while evaluating the effectiveness of using alcohol taxes as an alcohol control medium. In this study, I estimate the differential responses to alcohol prices on alcohol demand for young adults by asking whether heavy drinkers are more responsive to higher alcohol prices than light and moderate drinkers. To conduct the analysis, I use the data from the National Longitudinal Survey of Youth (NLSY97) for the years 1997 to 2008. To answer the research question on hand, I implement three different econometric methods: 1) Pooled quantile regression; 2) Quantile regression for panel data; and 3) Finite mixture models. Findings from these methods consistently suggest that heavy drinkers respond to higher alcohol prices by lowering their alcohol intake. Since alcohol-related externalities are likely to be caused by heavy drinkers, the results emphasize the possibility of higher alcohol taxes curbing alcohol-related externalities associated with young adults by lowering the alcohol consumption among heavy drinkers.

Key Words: Alcohol, Quantile Regression, Demand Model

JEL Codes: I18, I12, H23

1. INTRODUCTION

Alcohol taxes can be used as a revenue increasing mechanism. Simultaneously, economists have emphasized its use as a control device, which can be justified on Pigovian grounds.[2] However, nominal taxes on alcohol have remained fairly constant over the past two decades with few states opting for tax hikes. Federal excise taxes on alcohol have not risen since 1991 and both alcohol prices and taxes have not kept par with inflation.[3] Though several states have recently proposed increasing alcohol taxes, only a few such proposals have been passed into laws.[4] One reason for states' disinclination to raise alcohol taxes could be due to the fact that higher alcohol taxes also increase prices for responsible and light drinkers who do not necessarily need to be discouraged from drinking.[5] This study attempts to broaden the understanding of whether higher alcohol prices lower alcohol consumption among heavy drinkers.

There are two studies that directly analyze the differential effects of higher alcohol prices on alcohol consumption. Manning, Blumberg, and Moulton (1995) use data from the 1983 National Health Interview Survey (NHIS) and implement the quantile regression method to investigate the effect of higher alcohol prices on different levels of alcohol consumption. The authors find that moderate drinkers are much more elastic compared to light and heavy drinkers. Aayagari, Deb, Fletcher, Gallo, and Sindelar (2013) use the finite mixture model to account for the unobserved heterogeneity among the older individuals by using data from the Health and Retirement Survey (HRS). The authors find that higher alcohol prices lower alcohol consumption among light drinkers but do not affect the group that is comprised of heavy drinkers.

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[2] Grossman et al. (1994); Grossman, Chaloupka, Saffer, and Laixuthai (1994); Kenkel (1996); Markowitz (2000); Chaloupka, Grossman, and Saffer (2002)

[3] Prior literature suggests that tax hikes are more than fully passed through as price increases (Young and Kwapisz, 2002; Kenkel, 2005; Bergman and Hansen, 2009).

[4] In 2010, twenty-three states proposed increasing alcohol taxes, but all proposals were defeated. Source: http://usc.news21.com/johng-taxmap

[5] Another reason for the states being disinclined to raise alcohol excise taxes may be because of the influence of lobbies.

In this study, I use data from the National Longitudinal Survey of Youth (NLSY97) from 1997–2008 to estimate the differential effects of higher alcohol prices on alcohol demand among young adults. To investigate this research question and given the high proportion of non-drinkers in the sample, I use a two part model. The first part models an individual's decision to drink. The second part uses pooled quantile regression to analyze the differential effects of higher alcohol prices on alcohol consumption. The quantile regression method allows the effect of higher alcohol prices to vary across the conditional quantiles. I follow the analysis by implementing a penalized quantile regression approach for panel data proposed by Koenker (2004). The use of a penalized quantile regression approach helps to analyze the effect of higher alcohol prices throughout the conditional quantiles by controlling for the unobserved heterogeneity across individuals. Lastly, I use a finite mixture model to investigate the heterogeneous effects of higher alcohol prices on alcohol demand. The finite mixture model postulates that the draws are being made from subpopulations present in a larger population, hence allowing the effects of higher alcohol prices to vary by latent subgroups, which cannot possibly be identified by breaking the sample down according to age, gender, or consumption (Ayyagari et al. 2013). These econometric methods are discussed in more detail in section III.

This study makes four specific contributions to the existing literature. Mainly, it focuses on the heterogeneous effects of higher alcohol prices on alcohol demand among young adults who are 16 to 24 year olds. Several reasons motivate focusing towards this age group. First, these individuals are more likely to participate in abusive drinking, which increases the risk of traffic fatalities and other health hazards such as violent crime (Grossman, Chaloupka, Saffer, and Laixuthai 1994; Markowitz, 2000; Mast, Benson, and Rasmussen 1999). In 1995, fatalities per car miles of travel for people between the ages of 16 to 19 were more than twice as large as those of ages 25 and over (Dee and Evans 2001). Additionally, the National Highway Traffic Administration's annual reports demonstrate that drivers aged 21 to 24 consistently have the highest involvement in alcohol-related fatalities (NHTSA annual report, 2008). Second, evidence suggests that binge drinking might affect the academic performance of young adults (DeSimone, 2010; Sabia, 2010; Lindo, Swensen, and Waddell 2013). Third, alcohol consumption at this age may set a pattern for later consumption (Cook and Moore, 1999). Finally, drinking behavior during the transitional phase to adulthood may have a pertinent impact on human capital and family formation (Cook and Moore, 1993). However, despite the presence of such internalities and externalities associated with drinking, little is known about the heterogeneity in alcohol prices on alcohol demand for young adults (Ayyagari et al. 2013).

Second, this is the first study to use a relatively new quantile regression approach in a panel data setting to investigate the effect of higher alcohol prices on alcohol demand. In contrast, the study conducted by Manning et al. (1995) uses a quantile regression method in a cross-sectional framework for the year 1983. The extensive longitudinal nature of the dataset used in this study provides the opportunity to incorporate a panel data quantile regression approach (Koenker 2004, Lamarche 2010) to obtain better estimates of the price effects by respecting the longitudinal nature of the data. Such technique permits a researcher to estimate the price elasticity at various conditional quantiles by accounting for the unobserved heterogeneity across individuals.

Third, by using direct measures of ongoing state drinking sentiments, this study attempts to provide a better measure of price effects. In the studies performed by Manning et al. (1995) and Ayyagari et al. (2013), there is a concern about price effects being biased. The authors, in their studies, use across state variation in alcohol prices as a medium of identification and pay little attention to the unobserved factors that could be correlated to alcohol prices and alcohol consumption. One particular contender could be the states' drinking sentiments (Chaloupka et al. 2002; Manning et al. 1995). To account for the states' drinking attitude, I construct direct measures of state drinking sentiments by using variables generated from different data sources.[6] I use a Principal Component Analysis (PCA) to discover an underlying structure within these variables. The estimated factors are included in the regressions as controls.

Fourth, this study focuses on recent periods in the United States. This is important for two reasons. First, it is not clear whether the findings from earlier work pertain to the current situation. Manning et al.'s study use cross-sectional data from 1983. The drinking environment has changed since then as drinking as become relatively socially acceptable. Greenfield et al. (2007) reveals that the general public has become more tolerable towards drinking over the years. For example, in 1989, 47.7% of the survey participants supported an increase in alcohol taxes, whereas the number fell to 34.3% in 2005. Second, the matter of alcohol taxes is a current policy concern. Recently, Minnesota and Rhode Island passed bills that would raise taxes on alcohol. Moreover, in 2013 six states have proposed alcohol tax hikes.[7]

This paper has three main findings. From the pooled quantile regression method, I find that price effects are negative and statistically significant for relatively heavy drinkers. The price elasticities are -0.304 and -0.27 at 75th and 90th respective quantiles for current drinkers. Similarly, results from quantile regression for the panel data suggest that the price effects are concentrated at the higher end of the conditional distribution with the elasticity magnitude of -0.304 and -0.439 at the 75th and 90th respective quantiles. These results are in sharp contrast to the findings of Manning et al., which suggest that heavy drinkers are unresponsive to higher alcohol prices. Finally, using the finite mixture model, I discover two latent groups — one responsive to increases in alcohol prices and the other unresponsive. The findings suggest that the group responsive to higher alcohol prices is likely to be comprised of those who drink relatively more alcohol. The price elasticity associated to the responsive group is -0.428. The results further

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[6] Detailed discussion is provided in the data section.
[7] Source: https://alcoholjustice.org/watchdogging-2/legislative-activity?start=8

indicate that individuals prone to violence, drunk driving, and binge drinking are likely to fall under the group that is responsive to higher alcohol prices.

This paper proceeds as follows. Section II describes the data used in the study and discusses how the observed drinking sentiments are created. This is followed by a brief discussion of methods used in this study in Section III and presentation of the results in Section IV. Section V provides robustness checks. I compare my results to those of Manning et al. (1995) and Aayagari et al. (2011) in Section VI. Section VII contains my conclusions.

2. DATA

A. *National Longitudinal Survey of Youths 1997 (NLSY97)*

Data on alcohol consumption and other individual characteristics come from the National Longitudinal Survey of Youth — 1997 Cohort (NLSY97). NLSY sampled 9,022 youths aged 12-16 as of December 31, 1996. The first wave of the interviews was conducted in 1997 and the individuals were then followed annually. The last wave of interviews used by this study was in 2008. This is because the majority of the individuals in the study are over twenty-four years of age after 2008.

Each year, the respondents are asked about the number of days they used alcohol in the past 30 days prior to the survey date. If the respondent reports having participated in alcohol consumption in the 30 days prior to the interview, I regard him/her as a current drinker. Given that the respondent participated in drinking, he/she is asked information regarding the number of drinks consumed per drinking days. To capture the overall drinking behavior, I calculate drinks per month by multiplying the number of days an individual drinks per month and the usual number of drinks consumed each day. While performing empirical analysis, the top 2% of monthly drinks consumed is deleted, limiting the highest number of monthly drinks to 150.

The NLSY97 dataset consists of questionnaires related to involvement in violence and drunk driving, as well as mental health status. For instance, the respondent is asked if he/she had attacked anyone with the intention to hurt or fight in the interview year and if he/she participated in drunk driving. The American Academy of Child and Adolescent Psychiatry refers to "previous aggressive or violent behavior" as a risk factor that increases the likelihood of violent behavior (AACAP, 2012).[8] I classify a respondent at risk of demonstrating violent behavior if he/she has a history of violence by assigning a value of "1"; otherwise the respondent is given the value "0." Similarly, I create a separate dichotomous variable to indicate if the person engaged in drunk driving. Furthermore, the survey reports on the mental health of the respondent, and I use the depression scale as a proxy for his/her mental health status. The question asked is "How often has the respondent been depressed in the past month?" The options offered are: 1) Almost all of the time; 2) Most of the time; 3) Some of the time; and 4) None of the time. With these choices, I create a dichotomous variable and assign a value of "1" if a respondent reported being depressed some of the time or none of the time and "0" if the respondent reported being depressed all or most of the time. These variables are helpful in identifying if individuals prone to alcohol-related externalities are affected by higher alcohol prices. Besides specifically focusing on youths and young adults, the longitudinal nature of NLSY data provides the opportunity to include individual level fixed effects to account for unobserved heterogeneity.

B. *Alcohol Prices*

I use quarterly beer and wine prices to represent alcohol prices. The retail price of a six-pack of beer and a bottle of wine (750 ml) are obtained from the quarterly Council for Community and Economic Research (C2ER) cost of living index [C2ER is formerly known as American Chamber of Commerce Research Association (ACCRA)]. Liquor price is not

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[8] Source: http://www.aacap.org/AACAP/Families_and_Youth/Facts_for_Families/Facts_for_Families_Pages/Understanding_Violent_Behavior_In_Children_and_Adolescents_55.aspx

considered as C2ER stopped reporting the liquor prices after 2004. C2ER reports quarterly beer and wine prices for approximately 300 communities (cities or counties). I then generate a community population weighted state average, and deflate by the average cost of living of those communities and the 2006 Consumer Price Index (CPI). I aggregate prices to the state level to reduce measurement error, which could be caused by fewer observations belonging to a particular community. Since the dependent variable is the number of drinks per month, I calculate price per drink by using a standard drink size and applying equal weights for beer and wine prices.[9] Finally, I take log of price per drink for the ease of interpretation. The log of price per drink is then matched to the NLSY97 dataset by the state of residence, year, and quarter. Figure 1 shows the trend in real beer and wine prices over time and Figure 2 refers to the trend in price per drink.

Only a few states have changed their alcohol taxes over the time span of this study. Using alcohol prices instead of taxes provide us with an advantage in this regard as prices include variation not only from taxes, but also from differences in transportation, production, labor, and packaging costs and changes in the wholesale and retail distribution of alcohol.[10] Tremblay and Tremblay (2009) estimate that on the price of a typical six-pack of domestic beer, the taxes and shipping costs contribute to 17.2 percent of the price, packaging accounting for 16.5 percent, labor and production is 11.7 percent, and retail and distributor markup is 36.4 percent. Moreover, taxes alone contribute to a small portion of the price of alcohol. For instance, in my sample, the average price per standard drink is $ 1.24, whereas the average state tax per standard drink is $ 0.025, with tax constituting about 2 percent of price. This shows that, rather than tax, price is a better measure of the cost of alcohol. Referring to the cigarette market, Chow et al. (2006)

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[9] The Centers for Disease Control and Prevention (CDC) report standard drink sizes as 12 ounces for beer, 5 ounces for wine, and 1.5 ounces for liquor.

[10] The main identification strategy used in this study requires sufficient within-state variation in alcohol prices to properly identify the price elasticity of demand. To get a sense of the level of within-state variation in alcohol prices, I regress the log of price per standard drink on state fixed effects, year fixed effects, and other state-level variables, such as the measures of state drinking sentiments, the unemployment rate, population of 18 to 24 year olds, the legalization of medical marijuana, and the status of casino legalization. Such a regression gives an R-square of 0.80, suggesting that sufficient within-state variation is present in alcohol price even after the inclusion of state-fixed effects.

suggest that prices comprise of exogenous variation stemming from differences in transportation, and retailing costs, as well as the Herfindahl index among the states.

C. *Variables Reflecting Drinking Sentiments*

To mitigate the issue of omitted variable bias, I use seven different time-varying variables in the empirical framework to capture the states' drinking sentiments. Data for such variables are extracted from various sources. Detailed discussion regarding these variables and the data sources are presented as follows:

Legalized Casinos. Legalization of casino gambling is a controversial issue. A state's reluctance toward legalizing casinos could stem from moral objections to gambling and concerns over potential negative social impacts (Walker, 2009). The social cost of gambling can disseminate into the sectors of employment, bad debts and civil courts, and crime and treatment programs. Grinols and Mustard (2006) use a county-level analysis to show the rise in crime associated with casinos. However, one of the main reasons for legalizing casinos is to raise state revenues as gambling activities are relatively heavily taxed.

A state's preference towards casino gambling is used as a variable to absorb the respective state's sentiments towards sin. A dichotomous variable is created, which takes the value "1" if the respective state has passed the legislation approving commercial casinos at a given period; otherwise, the value given is "0."[11] The status of legalization of the commercial casinos is obtained from *The Washington Post* website and various state sources are used to locate the date bills legalizing casinos were passed.[12] Empirically, legalization of commercial casinos should be viewed as a time-varying variable. Before 1990, three states had legalized casinos; by 2006, casino gambling was legitimate in nine states.

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[11] Both riverboat casinos and land-based casinos are considered as commercial casinos. The casinos present on Indian reservations are excluded from the study.

[12] The sources are listed in the appendix.

Religion. Several past empirical papers in the field of alcohol consumption have included religion variables to proxy for the states' attitude towards drinking (Coate and Grossman, 1988; Mast et al., 1999; Grossman and Markowitz, 2005). This paper includes the rates of adherence (per 10,000 population) for Southern Baptists and the Church of Jesus Christ of Latter-Day Saints (hereafter shortened to Latter-Day Saints) to represent the states' religious composition. Due to the strong religious beliefs that oppose alcohol consumption, states with a high concentration of Southern Baptists or Latter-Day Saints are likely to have strong anti-sentiments towards drinking, which could lead to stringent alcohol control policies as a part of the political process. Hence, if such states are likely to have higher alcohol prices, failing to control for religious sentiments of the states could overstate the price effect.

Data for the respective religious variables used in this paper comes from the Association of Religious Data Archives (ARDA). ARDA publishes data regarding churches and church membership every ten years and the study is conducted within each county of the United States by the Association of Statisticians of American Religious Bodies (ASARB). Data for the years 1990, 2000, and 2010 were used to interpolate the religious variables for the years used in this study.

Employees in the Alcohol Industry. State legislatures are likely to support industries with a large number of employees (Benjamin and Dougan 1997; Feng 1998) and it is no different in the case of the alcohol industry. States that produce alcoholic beverages in a massive quantity, such as California (beer and wine), Missouri (Budweiser), Colorado (Coors), and Wisconsin (Miller) have relatively lower beer taxes. Similarly, the intensity of a lobbying effect could reflect upon the state's legislative actions. For instance, states with a strong lobbying command for beer could lead to low beer taxes.

The percentage of people working in the alcohol industry in a state is used as a proxy for both the respective state's economic importance of alcohol and its lobbying presence. First, the states' specific total number of people working in an alcohol industry (beer, wine, and distilled beverages) is collected by referring to the designated Standard Industrial Classification (SIC) code (for 1997) and the North American Classification System (NAICS) descriptions (for years 1998–2008) from the United States Census Bureau, County Business Pattern. Then the states' percentage of employed people working in the alcohol industry is calculated by using the total number of people employed in the labor market as the denominator. The resulting variable reflects the importance of the alcohol industry in a state. Employment numbers are extracted from the Bureau of Labor Statistics for the years used in this study.

Public Opinion. A state's specific culture and public perception regarding drinking could play a crucial role in designing a state's alcohol control polices, which also affects the level of drinking. Data reflecting the public attitude towards drinking is extracted from the National Survey on Drug Use and Health (NSDUH). One of the questions asked in the survey is, "How much do people risk harming themselves physically and in other ways when they have five or more drinks of alcoholic beverage once or twice a week?"[13] The Substance Abuse and Mental Health Statistics (SAMHSA) Office of Applied Studies (OAS) directly reports the state level data regarding the public perception of risk level attached to immoderate drinking divided by three age groups: 12 to 17, 18 to 25, and 26 or older. The percentage of 18 to 25–year-olds and those 26 years or older who reported a great risk of drinking (defined as five or more alcoholic beverages once or twice a week) is used as a variable representing how immoderate drinking is perceived in each states.[14] A limitation to this variable is that SAMHSA only reports data going back to 1999. Hence, to preserve the observations, missing values are replaced by state means. *Accessibility of Alcohol.* I control for the number of outlets licensed to sell alcohol and the percentage of a state's population living in dry counties with an intention to capture both the market structure effect and ongoing state sentiments regarding drinking. Data for both of these variables come from the *Adams Liquor Handbook.*

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[13] Options reported are: 1) No risk; 2) Slight risk; 3) Moderate risk; and 4) Great risk.

[14] The reason for selecting an older group of people is the likeliness of an older group having more of an influence in legislative activities.

Number of Exceptions. All states have laws against the possession of alcohol by minors and states also prohibit furnishing alcohol to minors. But some states are more lenient than others in this regard as they provide exceptions, including adults hosting underage drinking gatherings. I control for the number of exceptions provided by the respective state in order to account for leniency shown by the states towards underage drinking. Data regarding the number of exceptions come from the Alcohol Policy Information System (APIS).

Alcohol Impaired Driving Fatalities. To some extent, state differences in alcohol-related fatalities are likely to be influenced by the social attitude and knowledge towards drinking. For example, states with a high concentration of religious groups opposing drinking are more likely to have a low percentage of alcohol-related driving fatalities. Similarly, states with a high influence of public health forces and advocacy groups, such as Mothers Against Drinking and Driving (MADD), are less susceptible to alcohol-impaired driving fatalities. State variation in alcohol-related driving fatalities may signify a certain awareness towards drinking, which may be brought upon by changes in deterrence laws, public health campaigns against drunk driving, and social awareness. Ruhm (1996) suggests that several grassroots activities play a contributory role in reducing drunk driving by creating awareness and changing social attitudes towards drinking. Alcohol-related driving fatalities are used as a proxy for unobserved state-specific sentiment towards drunk driving — one of the major externalities of alcohol consumption. Data for alcohol-related fatalities come from the National Highway Traffic Safety Administration (NHTSA). Reported alcohol-related driving fatalities are determined by the annual number of crashes for which a driver's blood alcohol content (BAC) is greater than zero. To account for differences in population size, the percentage of alcohol-related fatalities are used.

D. *Other State Variables*

I include the state-level population for 18 to 24 year olds as a control for ongoing demographic changes in the states. Data for age specific population is obtained from the U.S.

Census Bureau. Considering the relationship between marijuana and alcohol established in earlier literature, legalization of medical marijuana use is used as a form of control (Cameron and Williams, 1999; DiNardo and Lemieux, 2001; Williams et al., 2004).

Table 1 shows the descriptive statistics of the NLSY sample along with the variables used to reflect the states' drinking sentiments. Due to the high correlation among the variables representing drinking sentiments, a Principal Component Analysis (PCA) is used as an approach to measure the drinking sentiments. Use of factor analyses is based on an assumption that an unobserved latent factor is responsible for the generation of variables used to capture the drinking attitude (DeCicca et al., 2008). Specifically, PCA — a type of exploratory factor analysis — is a variable reduction method that is used to discover the underlying structure within the data. PCA does so by generating the most important information from a given set of interrelated variables and extracting the principal components, which are the linear combinations of the observed variables. Each factor delineated by PCA defines a distinct cluster and can depict the pattern of the relationship between the correlated variables by forming descriptive categories.

Table 2 shows the results from PCA where *Panel A* presents the factor loadings. Three of the factors independent of each other are retained by maintaining the Kaiser criterion of preserving the factors with eigenvalues greater than 1 (Bandalos & Kaufman, 2009). The measure of uniqueness ranges from 0.88 to 0.15, suggesting that the overall factors explain between 12 and 85 percent of variance of the variables included in the data. The retained factors suggest that there are three independent patterns of relationships in the data. The sign and magnitude of the reported factor loadings portray how the variables influence each factor and also exhibit the intensity of their impact on the respective factors.

Although there is no proper benchmark for comparison, it is interesting to see the pattern of factor loadings in Table 2, *Panel A*. The first factor loads positively on public perception variables and negatively on liquor outlets. Factor 1 reflects anti-drinking sentiments just as risk (public perception) attached to alcohol consumption positively affects Factor 1. Consequently, the number of liquor outlets — a variable directly associated with pro-drinking sentiments — is inversely related to Factor 1. Factor 2 loads positively on Southern Baptists and percent dry, emphasizing the Southern Baptist religion. Factor 3 loads positively on alcohol importance, liquor outlets, drunk driving fatalities, and number of underage drinking exceptions, which a priori signals variables accentuating pro-drinking sentiments. Scoring coefficients, reported in Table 2, *Panel B*, are used to estimate three factors that are the linear combination of the observed variables. These factors are then used as control variables in regressions along with the status of state casino legalization.

3. METHODS

The model is specified in a way to analyze the effect of higher alcohol prices on alcohol consumption. The specification of the model used in the study is given below:

$$A_{ist} = f(Pa_{st}, B_{st}, D_{st}, Z_s, X_{ist}, y_t) \quad (1).$$

Equation (1) states that the alcohol consumption of an individual (i) living in a state (s) at time (t) is a function of alcohol prices an individual encounters (Pa_{st}), alcohol control laws (B_{st}), observed drinking sentiments of the state (D_{st}) represented by the estimated factors, state fixed effects (Z_s), individual and geographical characteristics (X_{ist}), and year fixed effects (y_t).

A. Two-Part Model with Pooled Quantile Regression

To identify the effects of higher alcohol prices on alcohol demand, I use a two-part model to determine an individual's drinking behavior. The first part models one's decision to drink by using a linear probability model. The regression model is given below:

$$C_{ist} = \beta_0 + \beta_1 \log(Pa_{st}) + \beta_2 B_{st} + \beta_3 D_{st} + \beta_4 X_{ist} + \beta_5 y_t + \beta_6 Z_s + e_{ist} \quad (2),$$

where C is a binary variable taking a value of “1” if the person reported having any drinks in the past 30 days; otherwise it has the value “0.” The other variables are as defined above. The second part then models the log of drinks consumed per month by the respondent if he/she has actually consumed alcohol. I first model the drinking behavior conditional on the respondent being a current drinker by using OLS:

$$log(A_{ist}) = \beta_0 + \beta_1 log(Pa_{ist}) + \beta_2 B_{st} + \beta_3 D_{st} + \beta_4 X_{ist} + \beta_5 y_t + \beta_6 Z_s + e_{ist} \quad (3),$$

where A_{ist} is the number of drinks consumed by an individual per month. Other variables are similar to those of equation (2). The coefficient on the log of alcohol prices in equation (3) can be interpreted as price elasticity for the current drinkers. For both the linear probability and OLS models, standard errors are clustered at the individual level.

The estimates of equation (3) focus on the conditional mean. To allow the effects of alcohol prices to vary across the distribution of the dependent variable, I estimate the model by using pooled quantile regression. For the τ^{th} quantile of the conditional distribution, the quantile regression model can be written as:

$$log(A_{ist}) = \beta_0 + \beta_{1\tau} log(Pa_{ist}) + \beta_{2\tau} B_{st} + \beta_{3\tau} D_{st} + \beta_{4\tau} X_{ist} + \beta_{5\tau} y_t + \beta_{6\tau} Z_s + e_{\tau ist} \quad (4),$$

where the coefficient of interest is $\beta_{1\tau}$, which represents the elasticity of alcohol demand at the τ^{th} conditional quantile. For the quantile regression estimates, to account for the within individual correlation, clustered bootstrapped standard errors by individuals are estimated from 299 replications. It should be noted that the estimates of elasticities might be misleading in the context of quantile regression. Similar elasticities across the quantiles can conceal the effects at higher quantiles by mitigating such effects. In the context of this study, the interest is the effect of higher alcohol prices on the number of drinks, as it is the number of drinks that drives the alcohol-related externalities and not the percent of drinks. Another advantage of quantile regression is the relevance of equivariance property (Cameron and Trivedi, 2009).[15]

B. *Quantile Regression for Panel Data*

Estimating equation (4) does not account for the variability in alcohol consumption occurring due to unobserved personal characteristics or "unobserved heterogeneity" across individuals. This may include a family's attitude towards drinking, one's preference towards drinking, and personality type. To do so, I consider the method of the penalized quantile regression estimator for panel data proposed by Koenker (2004) and further extended by Lamarche (2010). To obtain the estimates of penalized quantile regression method, Koenker (2004) proposes solving the minimization problem analogous to:

$$\sum_{j=1}^{J}\sum_{t=1}^{T}\sum_{i=1}^{N}\omega_j\rho_{\tau_j}\left(y_{ist}-\delta(\tau_j)log\ (Pa_{ist})-x_{ist}^{'}\beta(\tau_j)-\alpha_i\right)+\ \lambda\sum_{i=1}^{N}\rho_{0.5}(\alpha_i) \qquad (5),$$

where $\rho_{\tau_j}= u(\tau_j - I(u \leq 0))$ is the standard quantile loss function, ω_j is a relative weight given to the j^{th} quantile, α_i is the individual fixed effects for individual i, and λ operates as a tuning parameter. Similarly, y_{ist} in equation (5) represents $\log(A_{ist})$ from equation (4); $\log(Pa_{ist})$ is the price of alcohol; and $x_{ist}^{'}$ refers to a vector of other control variables included in equation (4) including the state fixed effects.[16] Here, the individual fixed effect, α_i, exerts a pure location shift as it does not depend on the conditional quantile, τ.

The proposed method simultaneously estimates the parameters $[\delta(\tau_j), \beta(\tau_j), \alpha_i]$ for the J quantiles. Estimating a large number of α parameters (individual fixed effects) may increase the variability of the parameters of interest. In the case of standard panel data, transformations such

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[15] The equivariance property defines that if $Q_\tau(lny|x) = X`\beta$ , then $Q_\tau(y|x) = \exp(lny|x) = \exp(X`\beta)$. The marginal effects is given as $\frac{\partial Q_\tau(y|x)}{\partial x_j}$ = $\exp(x`\beta_\tau)\beta_{\tau j}$. This can be obtained by predicting the conditional quantiles and multiplying the result by estimates of respective coefficients.

[16] About 20% of individuals changed states over time in my sample. State indicators are included in the model to account for these changes in location.

as mean differencing or first differencing are used to eliminate the fixed effect parameters. However, such transformations are not available in quantile regression. To reduce the variability in quantile regression method for panel data, minimization is performed over a weighted sum of quantile check functions with the inclusion of a penalty term $\lambda \sum_{i=1}^{N}(\alpha_i)$. The role of the penalty term is to shrink the individual fixed effects towards a common value. This may be beneficial in controlling the variability introduced by estimating a large number of α parameters. The tuning parameter λ is used to control the degree of shrinkage. When λ = 0, a fixed effect estimator is obtained; and when λ > 0, a penalized estimator with fixed effect is obtained (Billger and Lamarche, 2010). As λ approaches infinity, fixed effects are purged from the model and the estimates become pooled estimators.[17]

For the feasible estimation of equation (5), following Lamarche (2011), equally weighted quantiles are considered with $\omega = 1/J$. Selection of λ is of crucial importance as it helps reduce the additional variability introduced in the model by the estimation of individual effects (Koenker 2004, Lamarche 2010). Considering the empirically-based variance-minimizing strategy proposed by Lamarche (2010), selection of λ is given by:

$$\hat{\lambda} = \arg\inf \{tr \sum \delta\} \quad (6)$$

where $tr\sum$ is the trace of the covariance matrix of the quantile estimates.

The covariance matrix is computed by using the clustered bootstrap method. First, I randomly draw a respondent from the sample and include all the years of observations for that particular respondent. This process is repeated until there are *N* numbers of respondents where the draws are conducted with replacement. Second, with the new sample and a given value of λ, I compute the penalized quantile estimates illustrated by equation (5). Third, the first and second

[17] Please see Koenker (2004, 2005) and Lamarche (2010) for detailed methodology.

steps are repeated for B amount of times to obtain the standard errors. Finally, the above procedure is repeated for different values of λs (see Lamarche 2010).

C. *Finite Mixture Model*

The Finite Mixture Model (FMM) postulates that a random variable — in this case, observed number of drinks consumed — is drawn from a population, which is the additive mixture of C distinct subpopulations in proportions $\pi_1, \dots\dots\dots.., \pi_c$. The mixture density for observation $i, i = 1, \dots\dots.., n$ is given as follows:

$$f(A_i|\Theta,\pi) = \sum_{j=1}^{C} \pi_j f_j(A_i|\,\Theta_j), where\ 0 \le \pi_j \le 1, and\ \sum_{j=1}^{C} \pi_j = 1 \qquad (7),$$

where $f(A_i|\Theta,\pi)$ is the density of j^{th} component or subpopulation, π_j is the respective mixing probability, and Θ represents the remaining parameters. The mixture density is the weighted average of mixing probabilities and respective density functions, where the mixing probabilities (π_j) are assumed to be constant across observations.[18] The mixing probabilities are estimated along with the other parameters of the model by MLE. To constrain the mixing probabilities in order to have a positive value, π is parameterized as a logistic function and $\hat{\pi}$ is recovered by retransformation (Cameron and Trivedi, 2009). Robust standard errors clustered at the state level are obtained by using Stata's FMM package.

FMM has been applied in a variety of fields requiring statistical modeling of data, including economics (Heckman and Singer 1984; Wedel et al. 1993; Deb and Trivedi, 1997; and Ayyagari et al., 2011). The use of a finite mixture model is favorable for the purpose of this study as it supports the notion of heterogeneity by forming a small number of latent classes, which can be referred as "type" or "group." These latent classes may not be identified by merely breaking the sample according to observed characteristics like age, sex, and race. In this study, a two

[18] It should be noted that the probabilities can be allowed to vary by letting the (prior) component probabilities to be a function of observable characteristics (variable probability model).

component model is estimated by assuming parametric densities as negative binomial with quadratic variance for the components. A negative binomial is chosen as it is the most flexible and general way of modeling the pattern of over-dispersion among those available in the statistical literature for econometric models of count data (Cameron and Trivedi, 2009).

I use the estimated parameters from the finite mixture model to calculate the posterior probability of the observation being in each component by following Bayes's theorem:

$$\Pr(A_i\ \varepsilon\ class\ C \mid X_i, A_i, \Theta_i\ ) = \frac{\pi_C\ f_C(A_i|X_i,\Theta_C)}{\sum_{j=1}^{C}\pi_j f_j(A_i|\ X_i,\Theta_j)} \quad (8)$$

The estimated posterior probability varies across observations and is used to investigate the characteristics of the respective components. Predicted number of drinks for each of the components is calculated to explore the differences between the components according to monthly alcohol consumption.

One drawback of the finite mixture model is the risk of over-fitting the data such that the in-sample comparison may favor complex models even where there might be no gains in an out-of-sample forecast. This could be due to outliers or influential observations present in the data. The application of FMM should be supported by both reasons and meaningful a posteriori differences between the types (Deb and Trivedi, 1999).

The quantile regression technique is desirable to answer the research question of this study as it allows the effect of higher alcohol prices to vary across the quantiles of alcohol distribution. One alternative to the quantile regression method is to estimate binary models for the probability that the response variable exceeds some predetermined number of drinks consumed. Doing so may: 1) Result in a loss of information (in a sense that people consuming 45 drinks per month may be grouped in a same group with those consuming 25 drinks per month depending on the cutoff value); and 2) The researcher has to specify the cutoff values. The use of quantile regression is beneficial as the conditional quantiles are determined by the data.

The study proceeds by using the panel quantile regression method. Though pooled quantile regression allows the effect of higher alcohol prices to vary across the conditional quantiles, such a method does not account for individual specific factors, which could determine the consumption of alcohol. Such unobserved factors may include a family's attitude towards drinking, degree of health consciousness, one's personal preference towards drinking, and personality type (e.g., risk taking versus risk averse), which could bias the elasticity estimates if correlated to alcohol prices. By accounting for unobserved heterogeneity across individuals, the panel quantile regression method checks the credibility of the evidence from the pooled quantile regression. Due to this reason, the panel quantile method is preferred.

The use of a finite mixture model is an alternative way of detecting heterogeneity in the price elasticities of demand. It does so by forming a small number of latent classes, which can be referred to as "type" or "group." FMM is generally attractive if the mixture components have a natural interpretation (Ayyagari et al. 2013; Deb and Trivedi, 1999). Such an interpretation holds in my study. Between the two components, one can be classified as frequent drinkers and the other is composed of non-frequent drinkers. Furthermore, the use of a finite mixture model is helpful in characterizing the source of heterogeneity. With the estimation of posterior probability, a researcher can depict the characteristics of individuals who are likely to be affected by higher alcohol prices and those who are not. An alternative to FMM is to obtain price elasticity by interacting prices with the variables of interest, such as gender and race. Compared to such an approach, FMM is more general and allows the analysis by latent subtypes (Ayyagari et al., 2011).

4. RESULTS

A. *Results from Pooled Quantile Regression*

Table 3 presents the results from the two part model, where the first part is estimated by a linear probability model and the second part is estimated by using both OLS and quantile regression methods. Bootstrapped standard errors clustered by the respondent's ID obtained from 299 replications are presented in the parenthesis for the results pertaining to using a quantile regression method. The coefficient on log of price for the first part of the model illustrates that a 1% increase in the price of a drink is associated with reduction in drinking participation by 0.0083 percentage points. Though negative, the coefficient on the log of alcohol prices estimated by the linear probability model is statistically insignificant. The price elasticity for the drinkers estimated by OLS is -0.209 and is statistically significant at a 5% level. In other words, a 10% increase in the price of a drink is associated with a 2% reduction in monthly alcohol consumption at the conditional mean.

Price elasticities pertaining to the reported quantiles illustrate how the effect of higher prices varies along the conditional quantiles. Referring to the quantile estimates, the price elasticities are significant along the higher end of the conditional distribution. The price elasticity estimates are -0.11 and -0.19, respectively, at the 25th and 50th conditional quantiles and are statistically insignificant. The elasticities are -0.304 and -0.27, respectively, at the 75th and 90th conditional quantiles and are both significant at the 5% level. In other words, these results reject the hypothesis that relatively heavy drinkers have a perfectly inelastic demand curve. My findings are different from that of Manning et al's (1995), both in terms of the magnitude and the types of drinkers who are responsive according to the levels of alcohol consumption.

B. Penalized Quantile Regression Results

The Optimal λ. As stated by Lamarche (2010), the selection of λ is performed by minimizing the variance given by equation (6). Alternatively, an estimate for λ can be given by the following equation:

$$\hat{\lambda} = \arg\min \frac{1}{J} \sum_{j=1}^{J} \text{se}(\hat{\delta}\,(\tau_j, \lambda)) \qquad (9),$$

where the term se represents the standard error, and $\hat{\delta}(\tau_j, \lambda)$ is the price elasticity at a specific quantile τ. Figure 3 shows the relationship between the average standard error of the estimated price elasticities and various λs. Each point in Figure 3 presents the average standard error of the estimates of price elasticities estimated by equation (5) for the 25th, 50th, and 75th quantiles.[19] The solid line in Figure 3 illustrates $\hat{m}(\lambda)$ which is obtained by minimizing the cubic spline objective function:

$$L(m, \lambda) = \frac{1}{T} \sum_t \left\{ J^{-1} \sum_{j=1}^{J} \text{se}(\hat{\delta}(\tau_j, \lambda) - m(\lambda_t) \right\}^2 + \Theta \int \left(m''(\lambda_t) \right)^2 d\lambda \qquad (10),$$

where Θ penalizes the curvature.[20] According to Figure 3, the average standard error of the estimate decreases initially and then starts increasing. The smooth function $\hat{m}(\lambda)$ is minimized at the value λ = 0.5. Hence, λ = 0.5 is plugged into equation (5) to obtain the quantile estimates.

Quantile Regression Results for Panel Data. Table 4 presents the results from the quantile regression model for panel data. The first column shows that higher alcohol prices are associated with the reduction in drinking participation; however, the coefficient is insignificant at conventional levels. The OLS estimate suggests that higher alcohol prices are associated with a reduction in monthly alcohol consumption among the current drinkers with the price elasticity of -0.267. Moving to the quantile estimates, the magnitude of price elasticity increases with the

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[19] The standard error of the price elasticity estimate for a respective quantile is estimated by performing bootstrap replications with 1,000 repetitions (*B=1,000)*. This process is repeated for different values of λs ranging from 0.1 to 5 at every 0.1 interval. Hence, the selection of optimal λ depends on 50,000 bootstrap samples.

[20] For example, as $\Theta \to \infty$, any curvature is penalized infinitely, and as $\Theta \to 0$, we disregard the curvature. The value of Θ is selected by cross-validation.

reported quantiles. The price elasticity estimates are -0.138 and -0.153, respectively, for the 25th and 50th quantile and are statistically insignificant at the conventional levels. These estimates are similar to the ones from the pooled quantile regression. The results show that the effect of higher alcohol prices is concentrated at the higher conditional quantiles. The elasticity estimates are -0.304 and -0.439, respectively, at the 75th and 90th quantiles and are both significant at the 1% level. In other words, results suggest that relatively heavy drinkers respond to higher alcohol prices by reducing their monthly alcohol consumption. For instance, a 10% increase in price per standard drink is associated with a reduction in alcohol consumption by 3% and 4.4%, respectively, at the 75th and 90th conditional quantiles.

The quantile estimates on Factor 1 (representing anti-drinking sentiment) are negative for the second part of the model and are statistically significant at the higher conditional quantiles. The coefficients on Factor 2 (representing the Southern Baptist religion) are negative, but are statistically insignificant. Such imprecision could be the result of a lack of interstate variation among the variables representing the Southern Baptist religion. The estimates of pro-drinking sentiment represented by Factor 3 are positive among current drinkers, but are statistically insignificant across the reported quantiles (except at the 25th quantile).

C. *Finite Mixture Model Results*

Table 5 shows results from the finite mixture model. The difference between the two groups in terms of monthly alcohol consumption is illustrated by the predicted number of drinks presented in the bottom of Table 5. Estimation suggests that on average an individual in Component One consumes 5.33 drinks per month, whereas a person in Component Two consumes 26 drinks per month. Such differences created by FMM allows a researcher to explore the differential effects of alcohol prices on alcohol consumption. Respective price elasticity seems to be similar in magnitude for both the components, but is statistically significant only for the second component (at the 1% level). For instance, the coefficient on the log of alcohol prices for the second component suggest that a 10% increase in alcohol price is associated with a 4.3% of reduction in alcohol consumption among the group comprised of relatively heavy drinkers. This component is likely to consist of 40% of the sample. Consistent with the results from quantile regression, this finding indicates that relatively heavy drinkers are affected by higher alcohol prices.

The descriptive analysis of the posterior probabilities of being in component two (responsive component) of Table 5 is presented in Table 6 with an attempt to identify the characteristics correlated to the respective component. The first and second columns of Table 6 suggest that those whom reported having attacked someone in the interview year and binge drinkers are more likely to belong in Component Two. For instance, individuals that reported attacking someone is associated with an increased probability of being in the second component by 0.07 points on average. Column 2 shows that being mentally sound (not depressed) is associated with an increased likelihood of being in component two. Column 3 demonstrates that individuals who reported having participated in drinking and driving increases the probability of being in component 2. All columns consistently provide evidence that respondents with a high school degree or some level of college education are associated with the reduction in the likelihood of falling into Component Two compared to those with less than a high school education. Note that the sample size is reduced when compared to that of Table 5 as the questions regarding violence, mental health, and drunk driving were not asked for the full sample or were asked only in specific years. These findings suggest that the group that is responsive to higher alcohol prices is likely to consist of those who: 1) Drink and drive; 2) Have been involved in violent activities in the interview year; and/or 3) Participate in binge drinking. These results help explain the reduced form findings that advocate the role of higher alcohol taxes/prices in reducing traffic fatalities and violent crimes.

5. ROBUSTNESS CHECK

Several robustness checks are conducted to test the credibility of the results obtained in this study.

A. *Measurement Error*.

Young and Bielinska-Kwapisz (2003) and Ruhm et al. (2012) suggest that ACCRA data on alcohol prices contain measurement error. The inclusion of state fixed effect may exacerbate the issue of measurement error rather than mitigating it (Arellano, 2003). To address whether the results are being driven by measurement error after the inclusion of state fixed effects, I first exclude the state fixed effects. This allows me to use across-state variation in alcohol prices to identify the price elasticity. Second, I use alcohol taxes, instead of prices, and use specification that utilizes across-state variation in alcohol taxes to identify the tax elasticity. These results are presented in Table 7.

Column (1) of Table 7 replicates the findings from the model using state fixed effects from Table 3. Column (2) excludes the state fixed effects; column (3) presents results from using alcohol taxes; and column (4) uses alcohol taxes and excludes states having a state monopoly in wine. The results from the second part model for column (1) and (2) are quite similar. This provides the assurance that the inclusion of state-fixed effect is not exacerbating the potential measurement error in alcohol prices. The elasticity estimates obtained by OLS for the current drinkers of -0.209 (column 1) and -0.212 (column 2) are close to the price elasticity of -0.20, which was found by Nelson (2014) after conducting a meta-analysis of 191 estimates obtained from 114 primary studies.[21]

Alternatively, column (3) and (4) of Table 7 presents the results from using alcohol taxes instead of prices.[22] The tax estimates are of smaller magnitude than prices, but agree on the signs.

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[21] While obtaining the meta-analysis, Nelson (2014) addresses the issue of biases occurring due to differences in sampling and publication bias

[22] Similar to alcohol prices, I calculate tax per standard drink by using beer and wine taxes. Liquor taxes are not included due to considerable number of states holding state-monopoly in liquor distribution (18 states in 2000). In such cases taxes are difficult to determine. Source: http://alcoholpolicy.niaaa.nih.gov/

They are statistically significant at the conventional levels. Tax elasticities are likely to be lower in magnitude than prices as state alcohol taxes contribute to only about 2 percent of price per drink. Furthermore, if measurement error in alcohol prices is random and not systematically correlated to the number of drinks consumed by individuals, the measurement error will raise the standard errors but will not bias the results. It is unlikely that the measurement error occurring from ACCRA prices are correlated to the drinking pattern of the state.

Though Young and Bielinska-Kwapisz (2003) state that alcohol prices from ACCRA data may contain measurement error, this study does not directly establish concrete evidence regarding the presence of measurement error. Young and Bielinska-Kwapisz speculate that measurement error in alcohol prices may be introduced mainly by: 1) Local data collecting agencies due to their unfamiliarity in data collection processes; and 2) Prices being collected for only one brand for each type of beverage (beer, wine, and liquor). Following their discussion of measurement error, Ruhm et al. (2013) suggest using data collected from scanned barcodes on alcohol prices. Though desirable, the use of scanner data presents three main issues. First, such data is unavailable for liquor stores and other alcohol sellers, such as Costco and Walmart (Ruhm 2013). Second, the data is collected from only fifty-one markets (an example of a single market is Buffalo-Rochester). Due to such a relatively low number of markets in the sample, alcohol prices in one market may not be representative of an entire state. Third, scanner data of beer prices is available for only 35 states and wine prices for 25 states. Hence, further investigation may be fruitful in order to better understand the issue of measurement error in alcohol prices.[23]

B. *Zero Tolerance Law*.

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[23] ACCRA data is also widely used in obesity literature (Grossman and Mocan, 2011). One main limitation with ACCRA alcohol data is that prices are collected for only one brand of beer, wine, and liquor. Relying on such data would ignore the possibility of beverage substitution. Also, some measurement error can be introduced through the merging process.

Carpenter (2009) finds that zero tolerance laws reduced heavy episodic drinking by 13 percent among underage males. The first wave of NLSY interviews were conducted in 1997 and the last wave used in this study occurred in 2008. Eight states did not have zero tolerance laws before 1998 (Colorado, Louisiana, Montana, Nevada, North Dakota, South Carolina, South Dakota, and Wyoming). By 1998, all of the states had implemented a zero tolerance law. Table A1 (in the appendix section) shows the results for those models that include the zero tolerance law. Specification of column (1) includes the state fixed effect, whereas that of column (2) excludes the state fixed effect. The inclusion of a zero tolerance law does not affect the estimate of price effects. The coefficient on the zero tolerance law is positive for the models with state fixed effect. This may be due to the limited within-state variation in zero tolerance laws over the time span used in this study. Also, zero tolerance laws affect individuals under 21 and about 37.8 percent of respondents are over 21 (after one point) in my sample, which could contribute to having a no-effect of zero tolerance law.

C. *State Specific Linear Time Trends*.

Table A2 presents results from the two part model, where Model 1 includes state fixed effects and Model 2 includes individual fixed effects. The estimation is performed at the conditional mean. To test the robustness of the findings, both the models include a state-specific linear time trend, which captures any other linear state specific changes like culture and sentiments. The main results after including the state-specific time trends remain unchanged compared to the estimation performed at the conditional mean in Table 3 and Table 4. I also add the quadratic time trends instead of the state specific linear trends.[24] The results are virtually unchanged. This helps to provide a level of assurance that the price effects being captured in the previous models are unlikely to be confounded by state specific time-varying variables not accounted for in the model.

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[24] Results not shown but available upon request.

D. *Excluding Potentially Endogenous Variables*.

To address if potentially endogenous variables used to construct the measures of drinking sentiments are influencing the main findings of the study, I replicate the key findings by excluding employees in alcohol industry and traffic fatalities. Performing principal component analysis after excluding employees in alcohol industry and traffic fatalities retains two independent factors by following the Kaiser criterion of preserving the factors with eigenvalues greater than 1. The key finding of the study that relatively heavy drinkers respond to higher alcohol prices persists.[25]

6. COMPARISON TO EARLIER FINDINGS

Several studies have analyzed the effect of alcohol prices and taxes on alcohol consumption using the data from the National Longitudinal Survey of Youth (NLSY). The purpose of this section is to provide a general perspective of where the findings from this study fit in relation to those from earlier studies. Unfortunately, direct comparisons across studies are difficult due to the differences in regression framework (such as differing functional form, choice of method, and the use of independent and dependent variables) and timeframe of the sample.

Cook and Moore (1994) use data from the NLSY (1979) to estimate the effect of beer tax on alcohol consumption. The authors conclude that a higher beer tax reduces the probability of drinking participation and also decreases the level of alcohol consumption among the drinkers. Precisely, Cook and Moore (1994) conclude that a \$0.01 increase in tax per 12-ounce can of beer is associated with a reduction in alcohol consumption of 3.4 percent among the drinkers and reduces drinking participation by 2.6 percent. Hence, the authors encourage the use of a higher beer tax as an effective measure to reduce alcohol-related negative externalities, such as highway fatalities and crime. Keng (1998) estimates the effect of higher alcohol prices on the occasion of

[25] The Tables are presented in the Appendix section.

binge drinking by gender. The author's findings suggest that the effect of alcohol price is negative and statistically significant for men, but insignificant for women. Markowitz and Tauras (2009) use data from NLSY (1997) and focus on the teenage population. The authors find that a $1 increase in the price of beer is associated with reduction in drinking participation by about 4 percentage points.

Overall, my estimates of price elasticity (estimated at the conditional means) compared to the existing findings from NLSY data is modest. However, my elasticity estimates obtained by OLS for the current drinkers of -0.209 (Table 3) and -0.27 (Table 4) are close to the price elasticity of -0.20, which was found by Nelson (2014) after conducting a meta-analysis of 191 estimates obtained from 114 primary studies.[26] This study goes beyond the estimation performed at the conditional mean and explores whether heavy drinkers are responsive to higher alcohol prices. Unlike some previous studies (Manning et al., 1995; Aayagari et al., 2013) the findings of this study indicates that heavy drinkers respond to higher alcohol prices by decreasing their alcohol consumption. One reason for such a difference in the findings could be due to the age group of focus – Manning et al. (1995) focuses on individuals who are 18 years and older, whereas Aayagari et al. (2013) uses the data from the Health and Retirement Survey and limit their focus on older individuals. Young adults might not already have an established pattern of habit. Simultaneously, higher alcohol prices could decrease consumption among the heavy drinkers as alcohol expense is likely to comprise a bigger share of their budget than relatively light drinkers.

There exists an extensive literature that documents the effect of higher alcohol prices and taxes on the consequences of heavy drinking, such as alcohol-related deaths and traffic fatalities. Focusing on long term health effects of alcohol use, Cook and Tauchen (1982) find that higher

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[26] While obtaining the meta-analysis, Nelson (2014) addresses the issue of biases occurring due to differences in sampling and publication bias.

excise taxes on distilled spirits significantly reduce deaths from liver cirrhosis. The study conducted by Sloan, Reilly, and Schenzler (1994) concludes that increases in price of alcoholic beverages reduce suicides. Considering the scenario of alcohol related traffic deaths, several studies have analyzed the effect of higher alcohol prices and taxes on driving fatalities. Saffer and Grossman's (1987) findings suggest that higher alcohol taxes can reduce fatalities among 18 to 20 year olds. Furthermore, results from the study performed by Chaloupka, Saffer, and Grossman (1993) support such findings. Accounting for potential omitted variable bias by using state fixed effect model, Ruhm (1996) further confirms these past results by finding that higher alcohol taxes significantly reduce motor vehicle accidents.

Also, numerous studies have investigated the relationship of higher alcohol prices and taxes on crime. Using state level data from Uniform Crime Reports (1979 to 1987), Cook and Moore (1993b) conclude that higher beer taxes are associated with a significant reduction in rapes and robberies. Sloan et al. (1994b) find that increases in alcohol prices lower homicide rates. Markowitz and Grossman (1998, 2000) use data from National Family Violence Survey on children and conclude that higher alcohol taxes on beer can be an effective policy in reducing child abuse. In another study, Markowitz (2000) implements individual level fixed effect and finds that increases in price per ounce of pure alcohol reduce the probability of severe violence aimed at wives. In summary, the findings discussed indicate that increases in alcohol prices are an effective means in reducing cases of liver cirrhosis, traffic fatalities, alcohol related deaths and violence. The results from this study, which suggests that young adults who are relatively heavy drinkers respond to higher alcohol prices by reducing their alcohol consumption, supports such previous findings in the literature.

7. CONCLUSION

This paper uses data from the National Longitudinal Survey of Youths (NLSY97) to estimate the differential effects of higher alcohol prices on alcohol demand among young adults. To do this, I use a pooled quantile regression method and a relatively new quantile regression method for panel data proposed by Koenker (2004) and extended by Lamarche (2010). To better understand the source of heterogeneity, I further implement a finite mixture model to investigate whether young adults who are likely to participate in violence, drunk driving, and binge drinking are likely to respond to higher alcohol prices.

While the effect of higher alcohol prices is concentrated towards relatively heavy drinkers, the estimated price elasticities are modest and inelastic. Increasing the price of a drink by 10% is associated with a reduction in alcohol consumption by 3% and 2.6%, respectively, at the 75^{th} and 90^{th} conditional quantiles among current drinkers. Results from a quantile regression for panel data suggest that the price elasticity estimates are -0.3 and -0.43, respectively, at the 75^{th} and 90^{th} conditional quantiles. Using the finite mixture model, I uncover two groups — one that is unresponsive and one that is responsive to higher alcohol prices. The responsive group is likely to be comprised of relatively heavy drinkers with the elasticity estimate of -0.43. Examination of the posterior probability of the group responsive to increases in alcohol prices reveal that individuals prone to violence, drunk driving, and binge drinking are likely to respond to higher prices by decreasing their alcohol consumption.

The findings of this study are policy relevant as policy makers can increase alcohol prices by raising alcohol taxes, which will in return reduce alcohol consumption among the heavy drinkers. Alcohol-related externalities are concentrated towards young adults mainly in terms of drunk-driving and violence. In such context, increases in alcohol taxes can impose welfare gain by decreasing alcohol related externalities such as drunk driving and crime, which are mainly the outcomes of abusive drinking. The light or moderate drinkers are not responsive to higher alcohol prices, indicating that increase in taxes will result to little or no loss of welfare among this group.

The overall result supports the use of alcohol taxation as a revenue-increasing medium as it is an inelastic product (at least for the young adults' spectrum). While there is a growing concern regarding the issue of alcohol taxation at a political level, this study provides new findings that emphasize the possibility of higher alcohol taxes in reducing alcohol consumption among heavy drinkers.

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Figure 1. Trend in Beer and Wine Prices Over Time from C2ER

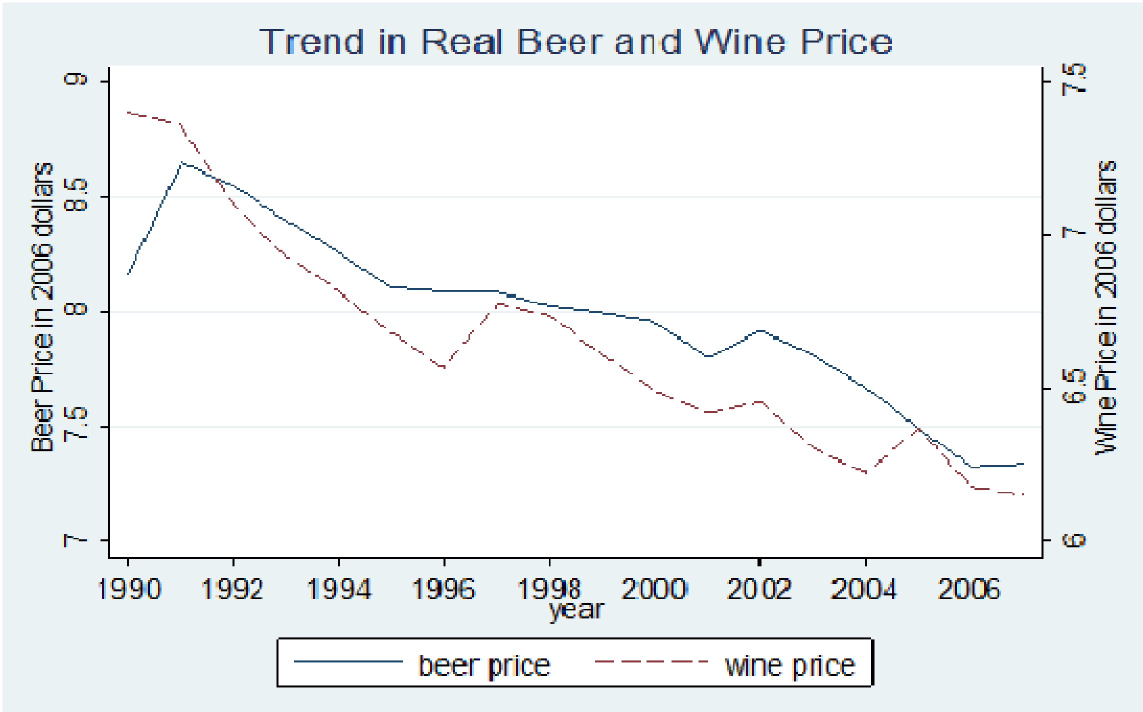


Figure 2. Trend in Price per Standard Drink

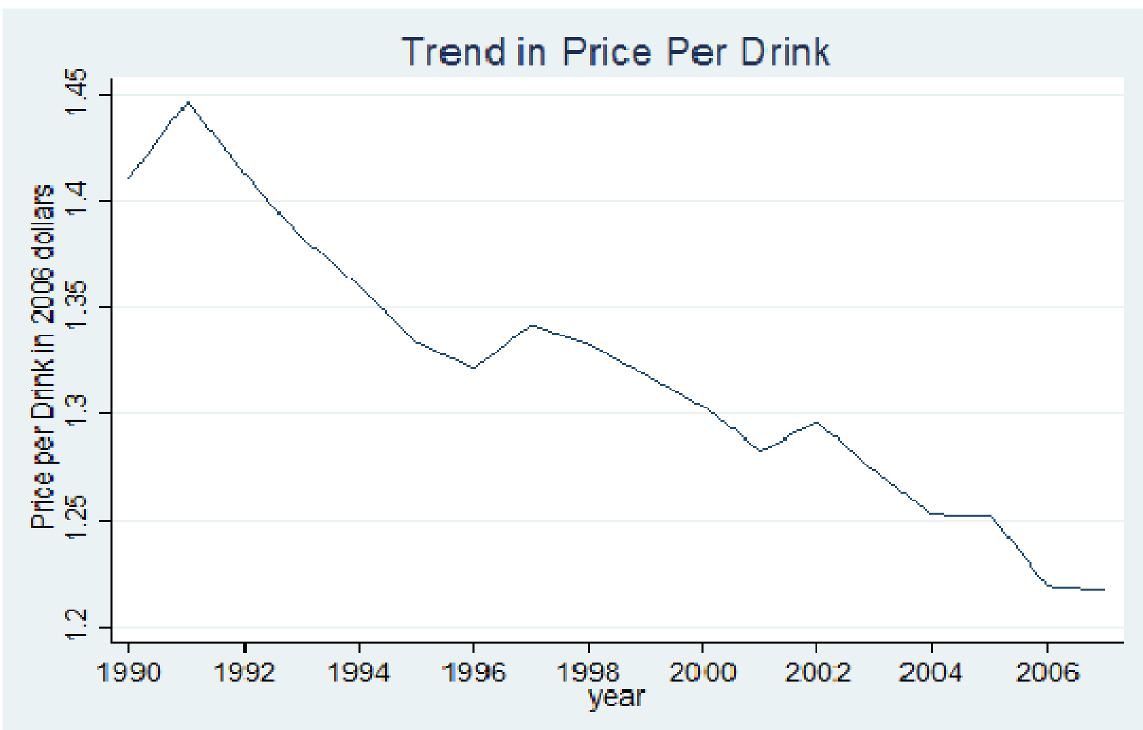
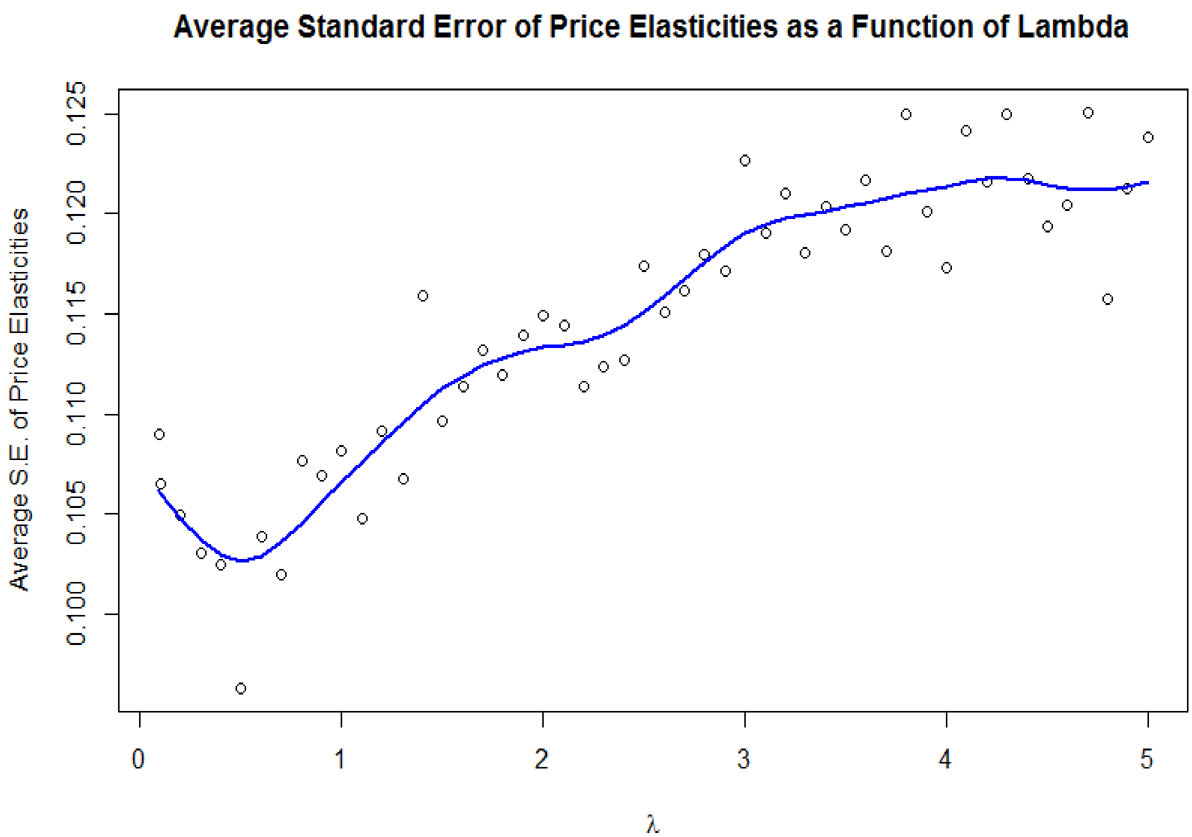


Figure 3. Selecting the Value of λ



Note: The figure above demonstrates how the value of λ is obtained. The average standard error of price elasticities for the 25th, 50th, and 75th quantiles estimated by bootstrap procedure are plotted as a function of λ. The solid line pertains to spline fitted along the estimated standard errors given by the dots.

Table 1. Summary Statistics

	Total Sample N=64,415		Current Drinkers N=34,197		Nondrinkers N=30,218	
Variables	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Dependent Variable						
Drinks per month	13.461	25.649	25.355	30.621		
Log of drinks per month			2.492	1.324		
Independent Variable						
Real beer price	7.581	1.181	7.523	1.172	7.646	1.188
Real wine price	6.159	1.185	6.081	1.171	6.248	1.196
Price per drink	1.239	0.203	1.226	0.200	1.253	0.206
Log (price per drink)	0.199	0.177	0.190	0.174	0.211	0.179
Personal Characteristics						
Income< $7,500	0.086	0.280	0.078	0.268	0.094	0.292
Income $7,500-24,999	0.147	0.354	0.152	0.359	0.141	0.348
Income $ 25,000-29,999	0.036	0.185	0.038	0.192	0.032	0.177
Income $ 30,000-49,999	0.121	0.326	0.131	0.337	0.110	0.313
Income $ 50,000 and over	0.611	0.488	0.601	0.490	0.622	0.485
Education missing	0.002	0.044	0.002	0.040	0.002	0.048
No high school	0.371	0.483	0.263	0.440	0.493	0.500
GED and high school	0.224	0.417	0.231	0.421	0.216	0.411
Some college	0.357	0.479	0.434	0.496	0.270	0.444
College graduate and more	0.047	0.211	0.071	0.257	0.019	0.136
Not married	0.814	0.389	0.852	0.355	0.770	0.421
Married	0.180	0.384	0.141	0.348	0.224	0.417
Separated, widowed, divorced	0.007	0.080	0.007	0.084	0.006	0.076
Blacks	0.263	0.440	0.186	0.389	0.350	0.477
Hispanics	0.209	0.407	0.197	0.398	0.223	0.416
Mixed race	0.010	0.098	0.010	0.098	0.010	0.098
Whites	0.518	0.500	0.607	0.488	0.417	0.493
Enrolled in school	0.490	0.500	0.458	0.498	0.526	0.499
Age	19.994	2.530	20.553	2.403	19.361	2.521
Over 21 (dummy=1)	0.439	0.496	0.536	0.499	0.328	0.470
Gender	1.506	0.500	1.487	0.500	1.528	0.499
Drinking Sentiments						
Panel A						
Latter-Day Saints	11.034	27.385	11.127	22.086	10.929	32.351
Southern Baptists	78.124	93.546	69.198	87.849	88.225	98.632

Public perception (25 and up)	45.442	4.478	44.829	4.515	46.135	4.332
Public perception (18 to 24)	33.955	5.225	33.250	5.261	34.754	5.066
Alcohol importance	1.205	0.225	1.215	0.229	1.195	0.220
Liquor outlets	1.055	0.546	1.092	0.548	1.013	0.542
Percent dry	2.726	7.761	2.211	6.947	3.309	8.553
Alcohol-related driving fatalities	24.736	4.270	24.919	4.225	24.529	4.310
Underage exceptions	1.287	0.927	1.314	0.931	1.257	0.921
<u>Panel B</u>						
Casino	0.189	0.391	0.195	0.396	0.182	0.386
State Variables						
State unemployment rate	5.052	1.089	5.094	1.085	5.004	1.093
Population 18 to 20	1,249278	1,047934	1,245875	1,059141	1,253129	1,035108
Medical marijuana use	0.182	0.385	0.194	0.395	0.168	0.374

Table 2. Results from Principal Component Analysis (NLSY data)
Panel A. Factor Loadings

Variable	**Factor 1 Loading**	**Factor 2 Loading**	**Factor 3 Loading**	**Uniqueness**
Alcohol importance	0.137	-0.244	0.703	0.427
Drunk driving fatalities	-0.289	0.363	0.714	0.274
Exceptions	0.055	-0.192	0.609	0.589
Liquor outlets	-0.635	-0.268	0.349	0.402
Public perception (25 and up)	0.907	0.163	-0.016	0.149
Public perception (18 to 25)	0.913	0.089	0.017	0.158
Latter-Day Saints	0.164	-0.288	-0.062	0.886
Percent dry	0.109	0.832	-0.102	0.286
Southern Baptist	0.41	0.786	0.068	0.209

Panel B. Scoring Coefficients

Variable	**Factor 1**	**Factor 2**	**Factor 3**
Alcohol importance	0.158	-0.16	0.479
Drunk driving fatalities	-0.142	0.298	0.470
Exceptions	0.104	-0.115	0.411
Liquor outlets	-0.230	-0.059	0.181
Public perception (25 and up)	0.401	-0.044	0.062
Public perception (18 to 25)	0.419	-0.091	0.083
Latter-Day Saints	0.12	-0.212	-0.037
Percent dry	-0.091	0.511	-0.038
Southern Baptist	0.071	0.437	0.098

Table 3. Results from Pooled Quantile Regression

	Drink Yes v. No	Quantity	25th Quantile	50th Quantile	75th Quantile	90th Quantile
Log (price per drink)	-0.008	-0.209[b]	-0.108	-0.189	-0.304[b]	-0.27[c]
	(0.020)	(0.089)	(0.170)	(0.147)	(0.133)	(0.147)
Factor 1	0.012	-0.043	-0.028	-0.079	-0.041	-0.012
	(0.009)	(0.032)	(0.086)	(0.068)	(0.060)	(0.063)
Factor 2	-0.023	-0.756	-0.125	-0.131	-0.051	0.003
	(0.019)	(0.059)	(0.136)	(0.116)	(0.084)	(0.079)
Factor 3	0.005	0.068[b]	0.095	0.082	0.043	0.006
	(0.008)	(0.028)	(0.090)	(0.073)	(0.077)	(0.106)
N	64,415	34,197	34,197	34,197	34,197	34,197

Note: The dependent variable for the first part model (prevalence) is drinking status (1=current drinker) and for the second part model is log of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, and state fixed effect. Robust standard errors clustered by a respondent's ID are reported in parenthesis for the first part and OLS estimations. Bootstrapped standard errors are clustered by the respondent's ID obtained after 299 replications are reported in parenthesis for the results pertaining to quantile regression. a = $p<0.01$, b = $p<0.05$, and c = $p<0.10$.

Table 4. Results from Quantile Regression for Panel Data

	Drink Yes v. No	Quantity	$\hat{\lambda}$	25th Quantile	50th Quantile	75th Quantile	90th Quantile
Log (price per drink)	-0.017	-0.267[a]	0.5	-0.138	-0.153	-0.304[a]	-0.439[a]
	(0.025)	(0.100)		(0.126)	(0.096)	(0.110)	(0.136)
Factor 1	0.017[c]	-0.013	0.5	0.008	-0.028	-0.063[b]	-0.094[b]
	(0.009)	(0.034)		(0.041)	(0.031)	(0.031)	(0.042)
Factor 2	-0.003	-0.053	0.5	-0.108	-0.020	-0.038	-0.125
	(0.017)	(0.073)		(0.081)	(0.069)	(0.070)	(0.086)
Factor 3	-0.009	0.026	0.5	0.076[b]	0.017	0.048	0.058
	(0.008)	(0.032)		(0.037)	(0.030)	(0.032)	(0.040)
N	64,415	34,197		34,197	34,197	34,197	34,197

Note: These are the estimates of a two part model, where the dependent variable of the first part model is drinking status (1=current drinker) and for the second part model is a log of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, and state fixed effect. Robust standard errors are clustered by a respondent's ID and are reported in parentheses for the first part and OLS estimations. Bootstrapped standard errors clustered by the respondent's ID are obtained after 1,000 replications are reported in parentheses for the results pertaining to quantile regression. a = p<0.01, b = p<0.05, and c = p<0.10.

Table 5. Finite Mixture Results

	Component1	Component2
Log (price per drink)	-0.456	-0.428[a]
	(0.373)	(0.112)
Age	0.243[a]	0.011
	(0.033)	(0.009)
Factor 1	-0.014	-0.048
	(0.114)	(0.039)
Factor 2	-0.245	-0.124[c]
	(0.244)	(0.074)
Factor 3	0.047	0.06
	(0.113)	(0.034)
Medical marijuana use	-0.301	-0.109[c]
	(0.236)	(0.084)
Unemployment	0.068	-0.0002
	(0.072)	(0.019)
predicted drinks per month	5.33	26
sum of posterior probabilities	0.59	0.41
N	64,415	64,415

Note: The dependent variable is the number of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, legalized casinos, and state fixed effects. Robust standard errors clustered by respondents are reported in parentheses. a = p<0.01, b = p<0.05, and c = p<0.10.

Table 6. Descriptive Analysis of Posterior Probability

	1	2	3
Attack anyone (yes=1)	0.073[a]	0.073[a]	
	(0.006)	(0.006)	
Binge	0.598[a]	0.598[a]	0.490[a]
	(0.010)	(0.010)	(0.010)
Drink and drive (yes=1)			0.080[a]
			(0.014)
Depressed (no=1)		-0.01[a]	
		(0.003)	
Education missing	0.020	0.020	0.051
	(0.061)	(0.061)	(0.064)
High school degree	-0.03[a]	-0.029[a]	-0.041[a]
	(0.006)	(0.006)	(0.008)
Some college	-0.035[a]	-0.035[a]	-0.03[a]
	(0.005)	(0.005)	(0.008)
College graduate and up	0.012	0.012	-0.008
	(0.016)	(0.016)	(0.018)
Married	0.021[a]	0.022[a]	0.066[a]
	(0.005)	(0.005)	(0.01)
Separated/divorced	0.050	0.05	0.054
	(0.031)	(0.031)	(0.032)
White	0.028[a]	0.028[a]	0.063[a]
	(0.007)	(0.007)	(0.008)
Hispanics	-0.015	-0.015	0.006
	(0.02)	(0.02)	(0.031)
Others	-0.003	-0.002	-0.021[a]
	(0.006)	(0.006)	(0.006)
N	43,620	43,605	10,428
R^2	0.4694	0.4694	0.4442

Note: The dependent variable is the estimated posterior probability of being in Component Two of Table 4. Additionally, the models include income dummies, state and year fixed effects. Robust standard errors are clustered by a respondent's ID are reported in parentheses. a = p<0.01, b = p<0.05, and c = p<0.10.

Table 7. Effect of Alcohol Prices and Taxes on Alcohol Consumption

	Effect of Alcohol Prices on Alcohol Consumption				Effect of Alcohol Taxes on Alcohol Consumption			
	(1)		(2)		(3)		(4)	
	Drink Yes v. No	Quantity	Drink Yes v. No	Quantity	Drink Yes v. No	Quantity	Drink Yes v. No	Quantity
Log(price per drink)	-0.008	-0.21[b]	-0.031	-0.212[b]				
	(0.020)	(0.089)	(0.023)	(0.084)				
Log(tax per drink)					0.002	-0.058[c]	0.004	-0.061[b]
					(0.009)	(0.03)	(0.009)	(0.030)
Factor1	0.012	-0.043	-0.023[a]	-0.028[b]	-0.027[a]	-0.032[b]	-0.022[a]	-0.034[b]
	(0.009)	(0.032)	(0.004)	(0.014)	(0.005)	(0.016)	(0.005)	(0.016)
Factor2	-0.023	-0.76	-0.007[c]	-0.007	-0.01[b]	-0.017	-0.013[a]	-0.021
	(0.019)	(0.059)	(0.004)	(0.015)	(0.004)	(0.014)	(0.004)	(0.015)
Factor3	0.005	0.068[b]	0.018[a]	0.027[b]	0.016[a]	0.017	0.014[a]	0.015
	(0.008)	(0.028)	(0.003)	(0.012)	(0.004)	(0.013)	(0.004)	(0.013)
N	64,415	34,197	64,415	34,197	64,415	34,197	61,685	32,748

Note: The dependent variable for the first part model (Drink, Yes v. No) is drinking status (1=current drinker) and for the second part model is log of drinks consumed per month. Column (1) controls for state fixed effects, year fixed effects and personal characteristics illustrated in the summary statistics table. Columns (2), (3) and (4) allows for across state variation in prices/taxes to identify the price effect and controls for personal characteristics illustrated in the summary statistics of the paper, year fixed effects, legalization of casinos, state with mass producing beer company, tourist market share, mandatory training for the employees, states requiring deposit while purchasing kegs, and information required to be recorded by the seller while purchasing kegs. Standard errors are clustered at the individual level. a = $p<0.01$, b = $p<0.05$, and c = $p<0.10$.

Table A1. Effect of Alcohol Prices on Alcohol Consumption with Zero Tolerance Law

	(1)		(2)	
	Drink Yes v. No	Quantity	Drink Yes v. No	Quantity
Log(price per drink)	-0.008	-0.209[b]	-0.031	-0.212[b]
	(0.024)	(0.092)	(0.023)	(0.084)
Factor 1	0.012	-0.043	-0.023[a]	-0.028[b]
	(0.009)	(0.032)	(0.004)	(0.014)
Factor 2	-0.023	-0.076	-0.007[c]	-0.007
	(0.016)	(0.063)	(0.004)	(0.015)
Factor 3	0.005	0.068[b]	0.018[a]	0.027[b]
	(0.008)	(0.029)	(0.003)	(0.012)
zero tolerance	0.002	0.025	-0.004	-0.009
	(0.038)	(0.183)	(0.038)	(0.184)
state fixed effect	Yes	Yes	No	No
N	64,415	34,197	64,415	34,197

Note: The dependent variable for the first part model (Drink, Yes v. No) is drinking status (1=current drinker) and for the second part model is log of drinks consumed per month. Column (1) controls for state fixed effects, year fixed effects and personal characteristics illustrated in the summary statistics table. Column (2) allows for across state variation in prices to identify the price effect and controls for personal characteristics illustrated in the summary statistics of the paper, year fixed effects, legalization of casinos, state with mass producing beer company, tourist market share, mandatory training for the employees, states requiring deposit while purchasing kegs, and information required to be recorded by the seller while purchasing kegs. Standard errors are clustered at the individual level. a = p<0.01, b = p<0.05, and c = p<0.10.

Appendix A2. Including State Specific Time Trends

	Model 1		Model 2	
	Drink Yes v. No	Quantity	Drink Yes v. No	FE
Log (price per drink)	-0.018	-0.269[a]	0.005	-0.348[a]
	(0.025)	(0.100)	(0.028)	(0.105)
Factor 1	0.017[b]	-0.014	0.006	-0.038
	(0.009)	(0.034)	(0.009)	(0.034)
Factor 2	-0.002	-0.055	-0.049[a]	-0.088
	(0.017)	(0.072)	(0.019)	(0.074)
Factor 3	-0.009	0.026	0.009	0.041
	(0.008)	(0.032)	(0.009)	(0.032)
Individual FE	No	No	Yes	Yes
State FE	Yes	Yes	No	No
State-specific time trend	Yes	Yes	Yes	Yes
N	64,415	34,197	64,415	34,197

Note: The dependent variable for the first part model (Drink, Yes v. No) is drinking status (1=current drinker) and for the second part model is the log of drinks consumed per month. Additionally, the models control for year fixed effects and personal characteristics illustrated in the summary statistics table (The only exception is that Model 2 only controls for the time-varying characteristics). Robust standard errors are clustered by a respondent's ID and are reported in parentheses. a = $p<0.01$, b = $p<0.05$, and c = $p<0.10$.

Table A3. Results from Pooled Quantile Regression

	Drink Yes v. No	Quantity	25th Quantile	50th Quantile	75th Quantile	90th Quantile
Log(price per drink)	-0.010	-0.183[b]	-0.04	-0.2	-0.29[b]	-0.269[b]
	(0.024)	(0.092)	(0.141)	(0.133)	(0.132)	(0.129)
Factor1	0.008	-0.058[c]	-0.031	-0.107[b]	-0.073	-0.035
	(0.009)	(0.035)	(0.058)	(0.049)	(0.046)	(0.043)
Factor2	-0.045[c]	-0.197[b]	-0.193	-0.352[a]	-0.206[c]	-0.121
	(0.026)	(0.096)	(0.132)	(0.115)	(0.109)	(0.105)
N	64,415	34,197	34,197	34,197	34,197	34,197

Note: The dependent variable for the first model (Drink, Yes v. No) is drinking status (1=current drinker) and for the second part model is log of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, and state fixed effect. Robust standard errors clustered by a respondent's ID are reported in parenthesis for the Drink, Yes v. No and Quantity estimations. Bootstrapped standard errors are clustered by the respondent's ID obtained after 199 replications are reported in parenthesis for the results pertaining to quantile regression. a = p<0.01, b = p<0.05, and c = p<0.10.

Table A4. Results from Quantile Regression for Panel Data

	Drink Yes v. No	Quantity	25th Quantile	50th Quantile	75th Quantile	90th Quantile
Log (price per drink)	-0.024	-0.268[a]	-0.192	-0.292[a]	-0.370[a]	-0.371[a]
	(0.025)	(0.100)	(0.125)	(0.091)	(0.105)	(0.128)
Factor 1	0.012	-0.041	0.009	-0.057	-0.059	0.027
	(0.010)	(0.038)	(0.048)	(0.040)	(0.036)	(0.011)
Factor 2	-0.022	-0.221[c]	-0.346[a]	-0.269[b]	-0.240[b]	0.261
	(0.028)	(0.112)	(0.130)	(0.108)	(0.111)	(0.170)
N	64,415	34,197	34,197	34,197	34,197	34,197

Note: These are the estimates of a two part model, where the dependent variable of the first part model is drinking status (1=current drinker) and for the second part model is a log of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, and state fixed effect. Robust standard errors are clustered by a respondent's ID and are reported in parentheses for the Drink, Yes v. No and Quantity estimations. Bootstrapped standard errors clustered by the respondent's ID are obtained after 1,000 replications are reported in parentheses for the results pertaining to quantile regression. a = $p<0.01$, b = $p<0.05$, and c = $p<0.10$.

Table A5. Finite Mixture Results

	Component1	Component2
Log(price per drink)	-0.507[c]	-0.419[a]
	(0.300)	(0.061)
Factor 1	-0.086	-0.088[b]
	(0.156)	(0.040)
Factor 2	-0.669[c]	-0.38[a]
	(0.398)	(0.072)
predicted drinks per month	5.34	25.97
sum of posterior probabilities	0.59	0.41
N	64,415	64,415

Note: The dependent variable is the number of drinks consumed per month. Additionally, the models control for personal characteristics illustrated in the summary statistics table, year fixed effects, legalized casinos, and state fixed effects. Robust standard errors clustered by respondent's ID are reported in parentheses. a = $p<0.01$, b = $p<0.05$, and c = $p<0.10$.

Appendix A6. Data sources of dates regarding the legalization of commercial casinos

a. Colorado: http://www.worldcasinodirectory.com/colorado
b. Illinois: http://www.worldcasinodirectory.com/illinois
c. Indiana: http://en.wikipedia.org/wiki/List_of_casinos_in_Indiana
d. Iowa: http://www.worldcasinodirectory.com/iowa
e. Louisiana: http://www.americancasinoguide.com/casinos-by-state/louisiana-casinos.html
f. Michigan: http://www.michiganinbrief.org/edition06/text/issues/issue-10.htm
g. Mississippi: http://mshistorynow.mdah.state.ms.us/articles/80/gambling-in-mississippi-its-early-history
h. Nevada: http://en.wikipedia.org/wiki/Nevada#Gambling_and_labor
i. South Dakota: http://usatoday30.usatoday.com/travel/destinations/2009-11-11-deadwood-gambling_N.htm

Chapter 2

Do Young Adults Substitute Alcohol for Cigarettes? Learning from the Master Settlement Agreement

Abstract

Although real alcohol prices have plummeted over the last two decades, cigarette prices have increased substantially, especially after the Master Settlement Agreement (MSA) in 1998. This study asks whether sizable increases in cigarette prices following the MSA altered the relationship between cigarettes and alcohol among young adults. Analyzing the data from the Behavioral Risk Factor Surveillance System from 1990 to 2008, I confirm four main findings: 1) Sizable increases in cigarette prices following the MSA altered the relationship between cigarettes and alcohol by influencing young adults to substitute alcohol for cigarettes; 2) The pattern of substitution is prevalent among light, moderate, and heavy drinkers; 3) The MSA led to an increase in alcohol consumption; and 4) Binge drinkers are more likely to substitute alcohol for cigarettes. These findings are supported by higher cigarette prices positively affecting alcohol-related driving fatalities in the years following the MSA.

Key Words: Alcohol Demand, Cigarette Prices, Substitutes, Complements

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1. Introduction

Policy makers have used higher taxes on cigarettes and alcohol as a medium to reduce externalities and increase revenues, though such measures have been deployed disproportionately. Nominal levels of federal excise taxes on alcohol have not risen since 1991 and states have been reluctant to increase alcohol taxes.[27] Thus, alcohol prices have failed to keep par with inflation (see Figure 1). In contrast, state-level excise taxes on cigarettes have increased numerous times over the past decades and the federal taxes on tobacco were last increased in 2009 to $1.01 per pack. President Obama's proposed fiscal budget for the year 2015 includes a further increase of 94 cents in federal taxes per pack of cigarettes; however, no increase in the alcohol tax rate has been reported. Policies aimed at discouraging the use of harmful substances such as cigarettes are often implemented without considering the effects of such policies on the consumption of other substances.

The harms related to alcohol consumption are well acknowledged, such as drunk driving fatalities, increased tendencies towards crime, the burden imposed on both public and private health insurance companies, and increased costs on the drinker and his or her family. Prior research analyzing alcohol demand concludes that higher alcohol taxes and prices reduce alcohol consumption.[28] Also, the majority of studies indicate that higher alcohol prices and taxes can reduce alcohol-related externalities, such as driving fatalities and crime.[29] However, only a handful of studies have considered the jointly determined nature of cigarettes and alcohol. These studies have produced mixed results; some suggesting that cigarettes and alcohol are complements of each other (Dee, 1999; Chaloupka et al., 1999; and Williams et al., 2004) and others claiming that they are substitutes (Decker and Swartz, 2000; Picone et al., 2004; Pacula,

[27] A reason for the states being disinclined to raise alcohol excise taxes may be due to the influence of lobbies.

[28] Grossman et al. (1993); Cook and Moore (1994); Grossman et al. (1994); Kenkel (1996); Markowitz (2000); and Chaloupka et al. (2002).

[29] Cook and Tauchen (1982); Saffer and Grossman's (1987); Sloan et al. (1994); and Markowitz and Grossman (1998, 2000).

1998; and Markowitz and Tauras, 2009). Whether cigarettes and alcohol are complements or substitutes remains an open question.

This study explores the effects of higher cigarette prices as a result of the tobacco settlement on alcohol demand among 18-to 24-year olds by analyzing the cross-sectional data from the Behavioral Risk Factor Surveillance System (BRFSS) from 1990 to 2008. Specifically, I examine whether the substantial increases in cigarette prices following the MSA altered the relationship between cigarettes and alcohol among young adults. In November 1998, four major tobacco companies settled the litigation commenced by attorney generals of 46 states to compensate health care expenses incurred by Medicaid. This well-publicized settlement, termed the Master Settlement Agreement (MSA), required tobacco companies to pay $206 billion to the states over a span of 25 years — the largest sum of money paid in any civil litigation in American history (Sloan and Trogdon, 2004; and Cutler et al., 2006). After the settlement, retail cigarette prices substantially increased. Such increases in cigarette prices offer a natural experiment to investigate the relationship between cigarettes and alcohol use, with the variation in prices originating from three sources: 1) Timing of the rise in cigarette prices; 2) Amount of the price increases; and 3) Increases in state-level excise taxes on cigarettes.[30]

Although focusing on the mean impact is important while highlighting the link between cigarettes and alcohol, relying on such estimates might mask potential heterogeneity in consumption. The concern of heterogeneity is of special interest in the case of alcohol consumption as prior research provides suggestive evidence that low levels of drinking are beneficial to one’s health (Dyer et al., 1980; Klatsky et al., 1981; and Marmot et al., 1981). In contrast, the majority of health risks and negative externalities associated with alcohol consumption arise from those who misuse alcohol (Grossman et al., 1994; Markowitz, 2000; and DeSimone, 2007). Understanding the heterogeneous effects of tobacco control policies on alcohol consumption according to the type of drinker is important when addressing the welfare effects of

[30] State-level variations in cigarette prices and taxes are presented in Figure A7 in the Appendix section.

such policies. Thus, another purpose of this paper is to analyze the effects of increases in cigarette prices among light, moderate, and heavy drinkers.

To investigate the heterogeneous responses to higher cigarette prices, this paper proceeds by applying two distinct methods: 1) A quantile regression method; and 2) A finite mixture model (FMM). Quantile regression allows for an examination of differential responses of alcohol demand to increases in cigarette prices by letting the effects vary across the conditional quantiles. A finite mixture model relaxes the assumption that observations are drawn from an identical distribution. Specifically, FMM postulates that the draws are being made from sub-populations present in a population; hence, allowing the effects to vary by latent sub-groups, which may not be identified by merely breaking down the sample according to some arbitrary characteristics such as gender or consumption level (Ayyagari et al., 2011). As a part of the analysis, I use regression discontinuity design to test whether the MSA changed the trend in alcohol consumption among young adults.

The findings suggest that higher cigarette prices arising from the MSA altered the relationship between cigarettes and alcohol use among young adults. As expected, the change in the relationship is pronounced among smokers. The results indicate complementarity between cigarettes and alcohol before the MSA, though the coefficients are imprecisely estimated. After the MSA, evidence suggests that increases in cigarette prices led young adults to substitute alcohol for cigarettes, changing the initial preference upheld between cigarettes and alcohol. Such a pattern of substitution is prevalent among light, moderate, and heavy drinkers. Results from RD design indicate that the MSA led to an increase in alcohol consumption among young adults. Findings from the FMM for 21-to-24 year olds indicate that increases in cigarette prices after the MSA increased alcohol consumption among the group (component), which is likely composed of individuals inclined towards binge drinking. These findings are further supported by higher cigarette prices being positively associated with alcohol-related fatal accidents in the years following the MSA.

This paper contributes to the literature concerning the interdependence between cigarettes and alcohol in several ways. First and most importantly, to my knowledge this is the first paper to analyze the effects of the MSA on the drinking habits of young adults by not just considering the participation decision, but also focusing on the intensity of alcohol consumption. Perhaps, due to the ease of a change in behaviors and not an already established pattern of habits, young adults are more likely to be susceptible to policy changes.[31] Moreover, young adults are more likely to participate in binge drinking, which is highly associated with cases of alcohol-related externalities, such as traffic fatalities and violent crime (Grossman et al., 1994; and Markowitz, 2000). Second, this study attempts to bridge the gap between the mixed findings of the prior literature on cigarettes and alcohol by taking advantage of large increases in cigarette prices occurring after the tobacco settlement. Specifically, a part of the study investigates if the relationship between cigarettes and alcohol evolved over time, which may further help explain the mixed findings. Third, this is the first study to examine whether the effects of increases in cigarette prices vary according to the levels of alcohol consumption. In other words, this paper shows how increases in cigarette prices affect alcohol consumption among light, moderate, and heavy drinkers. This helps us understand the gravity of the inadvertent effects of raising cigarette taxes. Fourth, the study contributes to our understanding of the underlying mechanism driving the substitution from cigarettes to alcohol. Fifth, this is the first study to investigate whether higher cigarette prices may create increases in alcohol-related driving fatalities. Finally, this paper informs policymakers by highlighting the unintended effects of higher cigarette prices, indicating that interdependence between cigarettes and alcohol should be considered when using higher cigarette taxes as a medium to discourage smoking.

[31] The National Highway Traffic Administration's annual reports demonstrate a consistency in drivers aged 21 to 24 having the highest incidence of involvement in alcohol-related fatalities (NHTSA annual report, 2008). For example, the 2007 statistics of NHTSA suggest that more than one third (35 percent) of 21-to-24-year old drivers were involved in alcohol-related fatal crashes (NHTSA annual report, 2008). Also, alcohol consumption at a younger age may set a pattern for later consumption (Cook and Moore, 1999). Finally, the drinking behavior during the transitional phase to adulthood may have a pertinent impact in human capital and family formation (Cook and Moore, 1993).

2. Conceptual Framework

Figure 3 shows the trend in alcohol consumption where the dashed line represents average drinks per month from the sample used in this study and the solid line indicates per capita beer consumption.[32] Both lines show decreasing trends in alcohol consumption in the first half of the 1990s, whereas the trends rise in late 1990s to 2003. One question that arises from Figure 3 is what explains the rise in alcohol consumption in the late 1990s.

Figure 1 shows the trend in real beer prices and taxes deflated to 2006 dollars by using the Consumer Price Index (CPI). Both the real beer prices and taxes have plummeted over the years as the states have failed to adequately pass legislation that would raise excise taxes on alcohol. Though it is likely that decreases in real beer prices can help explain the increasing trend in alcohol consumption during the late 1990s, such a notion is not consistent with the downward trend of alcohol consumption in the first half of the 1990s. In contrast, in the realm of tobacco control, several policy changes were made in the 1990s; specifically, by the well-publicized settlement, termed the Master Settlement Agreement (MSA).

On November 28, 1998, the attorney generals of 46 states and four major cigarette companies (Brown and Williams, Lorillard Tobacco Company, Phillip Morris, and R.J. Reynolds) entered into the Master Settlement Agreement. The litigation was brought upon by attorney generals of 46 states against the tobacco industry in order to recuperate the expenses incurred by the states' health insurance programs regarding tobacco-related illnesses. To achieve the main goals of the settlement, the agreement specified that the cigarette companies pay the states $206 billion over the span of 25 years, making it the litigation involving the largest sum of money paid in American history (Cutler et al., 2002; and Sloan and Trogdon, 2004). The two other main purposes of the settlement were to: 1) Diminish the use of tobacco consumption by youth; and 2) Shed awareness regarding the harmful aspects of tobacco consumption. To achieve

[32] It should be noted that the calculation of per-capita beer consumption does not restrict the age group; whereas, the focus of this study is on 18-to-24-year olds.

these goals, the settlement included several changes affecting the public perception of tobacco consumption. For instance, the MSA prohibited tobacco companies from marketing cigarettes to young individuals by blocking advertising, promoting, or marketing tobacco products on youth-based channels. Moreover, settling companies were limited in terms of tobacco brand name sponsorship, as they were not allowed to engage themselves in sponsoring activities that were composed of a significant percentage of youths in the audience.

After the settlement, the price of cigarettes increased for three main reasons: 1) The forward shifting of payment obligations from the tobacco companies to consumers; 2) Diminishing the price elasticity of demand from those who did not quit smoking; and 3) Increases in unavoidable taxes due to the ongoing publicity from the MSA (Sloan and Trogdon, 2003). Figure 2 shows the trend in cigarette prices and taxes from 1987 to 2008. In 1997, the national average of a real price of a cigarette pack in 2006 dollars was just under $2.50. By 2003, the national average of cigarette prices almost doubled and reached over $4. Although the MSA diminished the lobbying power of tobacco companies, state or federal average cigarette taxes did not rise until 2003. Such a pattern can be explained by a part of the settlement, which states that the tobacco companies were to be refunded any extra costs brought upon by the federal tobacco-related legislation until 2002 — be it taxes or any other means — with each settling participant receiving “a continuing dollar-for-dollar offset for any and all amounts paid” by the companies (Master Settlement Agreement). This study prefers using cigarette prices over taxes since cigarette taxes fail to capture the actual variation in the cost of cigarettes faced by consumers following the MSA.

Figure 4 shows the trend of real cigarette prices plotted along with the average drinks per month for all those who reported having consumed alcohol in the past month in the sample of this study. It is striking to note that the trend of average monthly drinks mirrors that of cigarette prices after the MSA. If higher cigarette prices indeed increased alcohol consumption, it would be by shifting the alcohol demand towards the right.

The extent to which alcohol consumption responds to changes in cigarette prices is not well understood in the current literature. There exists much conflicting evidence on the nature of the relationship between the two substances, some claiming substitutability and others indicating complementarity. Considering the substantial rise in cigarette prices after the MSA, two relevant questions arises: 1) Why might higher cigarette prices following the MSA affect alcohol demand; and 2) Did higher cigarette prices after the MSA alter the ongoing relationship between cigarettes and alcohol use among young adults? It should be noted that these two questions are quite different. The former is straightforward, but the latter asks precisely whether higher cigarette prices after the MSA changed the taste that existed in the pre-MSA period between cigarettes and alcohol among young adults. Discussing the potential mechanisms is important when answering these questions. The past literature focusing on cigarettes and alcohol does not address the mechanisms that may govern the relationship between these substances.

2A. Mechanisms

The first channel driving the relationship between cigarettes and alcohol after the MSA arises from the fundamental theory of substitution and income effects. Given that a person consumes both cigarettes and alcohol, economic theory suggests that sizable increases in cigarette prices after the MSA raises the opportunity cost of buying a pack of cigarettes making alcohol relatively cheaper than cigarettes. This might influence an individual to substitute alcohol for cigarettes (substitution effect). Substitution effect due to higher cigarette prices after the MSA will lead to an increase in alcohol consumption but will reduce cigarette consumption. On the other hand, increases in cigarette prices make an individual relatively poor by reducing his/her real purchasing power. This rotates the consumer's budget line inwards. An individual might thus reduce the consumption of both substances given that cigarettes and alcohol are normal goods (income effect).[33] If cigarettes and alcohol are complements, then increases in cigarette prices

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[33] A survey conducted in 2003 among a group of teenagers aged 12 to 17 reveal that relatively small increases in teens' disposable income approximately doubles the consumption and occurrence of alcohol

after the MSA are more likely to influence consumers to decrease consumption of both substances. In this case, substitution effect will be insignificant and income effect would easily dominate substitution effect. Similarly, if the two substances are substitutes, increases in cigarette prices would shift the alcohol demand towards the right. In this scenario, substitution effect dominates the income effect. In other words, change in alcohol demand after the MSA depends on substitution effect and the income effect which moves in opposite direction. The net effect of higher cigarette prices on alcohol consumption is theoretically ambiguous and relies upon empirical estimation.

When all things remain equal, in order for increases in cigarette prices to create a change in alcohol demand regardless of these substances being substitutes or complements, increases in cigarette prices should primarily reduce the quantity of cigarette demanded. Prior empirical evidence suggests that sizeable increases in cigarette prices after the MSA reduced smoking rates among youths and young adults (Sloan and Trogdon, 2004; Tauras et al., 2005; and Carpenter and Cook, 2007). Tauras et al. (2005), by focusing on youths and young adults, suggest that higher cigarette taxes and prices reduce smoking prevalence and the number of cigarettes smoked by current smokers. Carpenter and Cook (2007) find that even after including measures of anti-smoking sentiments in a cross-sectional model, cigarette taxes play a significant role in reducing smoking participation among youths.

The second scenario that could explain why the relationship between cigarettes and alcohol may be tempered after the MSA could be through MSA itself creating an explicit essence of anti-smoking sentiment and thus altering consumer's preference of cigarettes and alcohol. MSA received a huge publicity. Kenkel et al. (2006) indicate that anti-smoking sentiments

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intake (National Center of Addiction and Substance Abuse, 2003). Markowitz and Tauras (2009), using data from the National Longitudinal Survey of Youths, find that increases in young adults' income from allowances or earnings is associated with a higher probability of alcohol use. Using the reduced form, Adams and Cotti (2012) show that a higher minimum wage is associated with an increase in driving fatalities among youths. The authors argue that the mechanism works when a higher minimum wage increases the consumption of alcohol.

increased over the 1990s. Various public health campaigns against smoking originated in the 1990s and significant changes were implemented in tobacco control policies.[34] During this era of anti-smoking sentiments, MSA and higher cigarette prices after the tobacco settlement may have presented a clear and virtual message regarding the social stigma attached to smoking. Such a rise in anti-smoking sentiment may have changed consumer's tastes by altering how one perceives cigarettes and alcohol besides just the price effects. A rise in anti-smoking sentiments may create a spur in pro-drinking sentiments in a relative sense, since alcohol consumption is now more socially acceptable than cigarette smoking. Apart from pure price effects, higher cigarette prices after the MSA could create an increased substitutability into a consumer's taste due to: 1) The rising anti-smoking sentiments throughout the 1990s and sizable increases in cigarette prices after the MSA working as a trigger mechanism making the switch from cigarettes to alcohol easier; and 2) Increases in cigarette price potentially demonstrating the harmful aspects of smoking. Whether the effect of higher cigarette prices on alcohol consumption is being driven through such an indirect channel is testable, which is discussed later in this study.

Lastly, tobacco and alcohol are often referred to as "gateway drugs," with consumption being driven by sociocultural (e.g., peer pressure influences) and biological factors (e.g., a family history of substance use) (Meyers and Kelly, 2006). The reduction in smoking participation following the settlement may have further decreased smoking rates due to peer influences. This could lower ones' exposure to substances, such as alcohol, given the strong association between the two substances, and hence, decrease alcohol consumption.

In summary, higher cigarette prices will shift alcohol demand towards the right if the substitution effect dominates the income effect and will push alcohol demand towards the left if the income effect is larger than the substitution effect. The MSA and substantial increases in

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[34] Parents Against Smoking was launched in 1990. Also, domestic airline flights of less than six hours duration banned smoking. Several states started passing smoking bans in restaurants and/or workplaces. The Synar Amendment, establishing a minimum age for tobacco sales, passed in 1992, and went into effect in 1996. The Master Settlement Agreement was signed in November 1998.

cigarette prices after the MSA may explicitly create anti-smoking sentiments, which can in turn increase pro-drinking sentiments and lead to an increase in alcohol consumption. Finally, peer influences may lead to a reduction in alcohol demand, given the close association of these two substances. Ultimately, how higher cigarette prices after the MSA affected alcohol consumption remains an empirical question.

Besides the economic pathways that connect cigarettes and alcohol, medical research provides substantial evidence regarding the joint consumption of the two substances. A closer look at the physiological connection between cigarettes and alcohol use can further help our understanding of why alcohol demand might be affected due to substantial increases in cigarette prices.

2B. Can Higher Cigarette Prices Affect Alcohol Consumption through Physiological Channels?

A huge body of medical research supports the claim that alcohol and cigarette consumption often occur together. By examining inpatients in an alcohol treatment facility, Bobo et al. (1987) estimate that about 75 to 100 percent of the patients also smoke cigarettes. Given the notion that inpatients in alcohol treatment facilities are likely to be heavy drinkers, the statistics in this study suggest that heavy drinkers are prone to smoking. A relatively recent study conducted by Ritchey et al. (2001) examines a sample of high school students in America. The authors find that drinkers are three times more likely than non-drinkers to be smokers (Ritchey et al., 2001). Moreover, Robin (2003) suggests that since drinking is more prevalent than smoking, smoking is a better predictor of drinking rather than the inverse (Robin, 2003). Findings from prior research reveal that the association between smoking and drinking varies with the intensity of drinking. By examining a non-treatment population, Craig and Van Natta (1977) find a highly statistically significant association between the amount of smoking and drinking. The authors further suggest that the degree of positive association is greater among the heavy drinkers.

The strong connection between smoking and drinking is driven by both biological and psychological factors. Pharmacologically, nicotine and ethanol are used to counteract the effects of one another as ethanol is a depressant and nicotine is a stimulant. Psychologically, specific personality traits like impulsiveness and sensation-seeking are related to heavy drinking and smoking (Little, 2000). Also, smoking can prompt drinking and vice-versa, each acting as cues for one another (Room, 2003). Hence, relying solely upon such medical evidence, it is predicted that higher cigarette prices following the MSA will shift alcohol demand towards the left, reducing alcohol consumption through a decrease in cigarette smoking.

After discussing the mechanisms through which higher cigarette prices after the MSA influence alcohol demand, a procedure to empirically estimate such a relationship is formulated.

2C. Alcohol Demand Function, Cigarette Prices, and the Reduced Form

The determinants of alcohol and cigarette consumption can be written as:

$$A_{ist} = k(C_{ist}, Pa_{st}, B_{st}, X_{ist}, s_s, y_t, e_{ist}), \text{ and} \quad (1)$$

$$C_{ist} = g(Pc_{st}, A_{ist}, M_{st}, X_{ist}, s_s, y_t, e_{ist}) \quad (2)$$

Equation (1) states that alcohol consumption (A_{ist}) of individual i at time t living in state s is a function of cigarette consumption (C_{ist}), alcohol prices (Pa_{st}), other alcohol control policies of the state (B_{st}), other individual and geographical characteristics (X_{ist}), state-level perception towards drinking which is proxied by the state fixed effects (s_s), year effects (y_t) which captures the change in drinking trend common to all states, and the residual term (e_{ist}). Relying on the relationship established by estimating equation (1) is vastly misleading when assessing if cigarettes and alcohol are complements or substitutes, as it is likely that third factors, such as biological and psychological aspects, may drive the consumption of both cigarettes and alcohol. Similarly, equation (2) demonstrates the determinants of cigarette demand (C_{ist}), where Pc_{st} represents cigarette price per pack in state (s) at time (t), M_{st} refers to other smoking policies (e.g., smoking bans in bars), and s_s refers to state fixed effects..

To empirically determine the link between cigarettes and alcohol use, the reduced form model is specified below. Equation (3) is obtained by substituting a plausibly exogenous determinant of cigarette consumption — cigarette prices, given by equation (2) into equation (1).

$$A_{ist} = f(Pc_{st}, Pa_{st}, B_{ts}, X_{ist}, s_s, y_t, e_{ist}). \tag{3}$$

Equation (3) serves two main purposes. First, it helps examine the direct effect of cigarette prices on alcohol consumption, aiming at policy measures. Second, by declaring alcohol consumption as a direct function of cigarette prices rather than cigarette consumption, it makes an assertion that cigarette prices affect alcohol intake only through cigarette consumption. Thus, the model helps trace the link between cigarettes and alcohol by using arguably exogenous determinants of cigarette consumption, such as cigarette prices. The sign on the coefficient of cigarette prices will allow a researcher to determine if cigarettes and alcohol are substitutes or complements. A positive sign implies that higher cigarette prices are associated with an increase in alcohol consumption, therefore suggesting that cigarettes and alcohol are substitutes. Similarly, a negative coefficient on cigarette price is suggestive of complementarity between the two substances.

3. Data

3A. Behavioral Risk Factor Surveillance System (BRFSS)

Data on alcohol consumption and other individual characteristics comes from the Behavior Risk Factor Surveillance System (BRFSS) from 1990 to 2008. The BRFSS is an annual survey conducted by Centers for Disease Control and Prevention (CDC), which consist of nationally representative samples of individuals with a comparatively large sample size. The dataset is designed to address health issues in the U.S. and consists of questionnaires related to smoking, alcohol use, physical inactivity, diet, and hypertension. The survey also covers a wide range of other health topics. Questions reflecting the drinking behavior of individuals asked are the number of days an individual drinks in a month and the average number of drinks a respondent consumes when he/she drinks. To capture overall drinking behavior, the number of drinks a person consumes per month is used as the dependent variable in this study. 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.[35] While performing an empirical analysis, the top 2 percent of monthly drinks consumed is deleted, limiting the highest number of monthly drinks to 150.[36]

Apart from the BRFSS sample being a nationally representative survey with a large sample size; it contains a relatively rich set of socioeconomic and demographic characteristics, which are shown in the summary statistics table (Table 1). The personal characteristics included in this research are income, age, gender, race, employment status, and marital status. Moreover, respondents report their state of residence, which allows for merging state-level variables with each observation. This study excludes observations from Puerto Rico, Guam, and the Virgin Islands, thus restricting the sample to 50 states and the District of Columbia. Since the study is related to individuals who are 18-to-24-year olds, those respondents who are above 24 are not considered. Finally, those observations with missing values for the number of drinks consumed per month are discarded. I exclude survey years 1994, 1996, 1998, and 2000 from my sample as only a handful of states were asked alcohol-related questionnaires.

3B. Cigarette Prices and Smoke-Free Air Laws

The main variable of interest in this study is the price of cigarettes. Data for cigarette prices originates from the *Tax Burden on Tobacco* (Orzechowski and Walker, 2011). The prices used are the weighted averages (by market share) for a pack of 20 cigarettes and are inclusive of taxes. Cigarette prices are then converted to the real terms equivalent of 2006 dollars by using the Consumer Price Index (CPI). The price of a pack of cigarettes is considered rather than the tax since price is a better measure of the cost of cigarettes. Price captures the exogenous variations generating from differences in transportation costs, retailing costs, and the Herfindahl index

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[35] Current drinkers in this case are defined as those individuals who had one or more drinks in the past 30 days and non-drinkers are defined as those who reported not consuming any alcoholic beverage in the past 30 days.

[36] This limitation is provided in order to avoid the extreme outliers, defined as those who drink more than 5 drinks per day for all 30 days of the month.

among states (see Chou et al., 2006 for details). Figure 5 shows the scatter plot of cigarette prices in different states over time, where each dot represents the price per pack in a respective state. The figure shows that cigarette prices in all states start to rise after the MSA. Similarly, across-state variation in cigarette prices increases after the MSA. Figure 2 displays the trend in real cigarette prices and taxes equivalent to 2006 dollars. Referring to Figure 2, cigarette taxes did not start rising until 2003. Hence, making use of cigarette taxes discards the significant variation in prices occurring right after the tobacco settlement and acts as an improper measure of cost per pack of cigarettes from a consumer's viewpoint. For instance, following the settlement, both Philip Morris and R.J. Reynolds announced the imminent increase in cigarette prices of 45 cent per pack as a result of the designated payment associated with the MSA.[37] Such a forward shifting of payment obligation towards the consumers will not be captured by cigarette taxes.

The measures of smoke-free air (SFA) laws are absent from the main specification and are considered only in alternate specifications. This is primarily due to two factors: 1) It is unclear as to whether these laws are effective at reducing smoking. One strand of literature advocates the effectiveness of these laws (Wasserman et al., 1991; Chaloupka, 1992; and Evans et al., 1999), whereas recent findings provide evidence against the effectiveness of SFAs (Owyang and Vermann, 2011; Shetty et al., 2011; Carpenter et al., 2011, Adda and Cornaglia, 2010; and Bitler et al., 2010); and 2) It is unlikely that smoking bans and restrictions, with exception of bans in bars, will have a direct effect on an individual's drinking behavior. Inclusion of these laws merely exacerbates the concern of colleniearity as both cigarette prices and SFA laws might be originating from a same data generating process

In alternate specifications, the regulation banning smoking is used in three different areas — bars, restaurants, and private workplaces — as a measure of SFA laws. To portray the SFA laws of a specific state, a dichotomous variable is constructed assigning a value of "1" if the state imposes a smoking ban in bars; otherwise, the value given is "0." Similarly, separate

[37] Source: http://www.nytimes.com/1998/11/24/us/cigarette-makers-announce-large-price-rise.html

dichotomous variables are constructed for bans imposed in restaurants and private workplaces each year. The indicator variable for bans in bars, restaurants, and workplaces are included separately in alternate specifications in order to reduce the concern of multicolleniearity. The number of smoking restrictions established in various places, is also considered including bars, malls, private workplaces, school areas, governmental places, restaurants, child care center, and public transit, to test the robustness of the findings from the main specification.

3C. Alcohol Prices and Policies

Beer prices are used to represent alcohol prices since beer is the most popular alcoholic beverage of choice both among the age groups in this study and also in terms of consumption of pure ethanol per capita (Beer Institute). The retail price of a 6-pack of beer is obtained from the quarterly American Chamber of Commerce Research Association (ACCRA) Cost of Living Index, currently known as the Council for Community and Economic Research (C2ER). C2ER beer prices are measured at the community level (cities or counties). The prices are then aggregated to the state level to reduce measurement error, which could arise from fewer observations belonging to a particular community. State-level quarterly beer prices are converted to 2006 dollars by using the CPI. The prices are then matched to the BRFSS dataset by the state of residence, year, and quarter. The use of prices is beneficial compared to taxes as prices not only capture the variation from taxes but also consider differences in production, packaging, advertisement, transportation costs; and markup (Tremblay and Tremblay, 2009). However, the issue of measurement error is potentially prevalent in prices, which is problematic if it is systematically related to alcohol consumption. If the measurement error is of a classical type, the coefficient on alcohol prices will be biased downwards.

Four other areas of alcohol control policies that are considered in this study are keg control policies, drinking and driving laws, laws applicable to selling alcoholic beverages, and retail sales law. Information regarding each of these laws is obtained from the National Institute on Alcohol Abuse and Alcoholism's online database called the Alcohol Policy Information System (APIS). Details regarding these laws are provided in Appendix 1.

4. Identification Strategy and Empirical Methods

The effect of higher cigarette prices on alcohol consumption is identified by using within state variation in cigarette prices over time. As shown in Figure 1A (Appendix), cigarette prices increased over time. The variation in cigarette prices is generated by three main factors: 1) Timing of increases in cigarette prices; 2) The magnitude of increase in prices; and 3) Increases in cigarette taxes.

A two-part model is used to model an individual's drinking behavior while considering the effects on both the intensive and extensive margins. One's decision to drink and how much to drink could originate from two different sources, which motivates a separate modeling of an individual's decision to drink and the number of drinks consumed, given that the person drinks. The essence of a two-part model is to decompose one observed random variable (drinks consumed in a month) into two observed random variables (Manning et al., 1995). The first part estimates equation (3) by a linear probability model on whether or not the person consumed any alcoholic beverage in past 30 days. Current drinkers are defined as individuals who had one or more drinks in the past month. The regression model for the first part is given below.

$$\mathrm{D_{ist}} = \delta_1 + \delta_2 \mathrm{Pc_{st}} + \delta_3 \mathrm{Post.MSA} * \mathrm{Pc_{st}} + \delta_4 \mathrm{Pa_{st}} + \delta_5 \mathrm{B_{st}} + \delta_6 \mathrm{X_{ist}} + \delta_7 \mathrm{s_s} + \delta_8 \mathrm{y_t} + \mathrm{e_{ist}} \quad (4)$$

D here is a binary variable taking a value of "1" if the person reported having any drinks during the past 30 days; otherwise, it takes the value of "0". The other variables are defined in equation (3).

The second part then models the log of drinks consumed per month by the respondent if he/she drinks. Log transformation is used for four main reasons: 1) Log transformation reduces the skewness of the distribution among the drinkers, though it does not completely eradicate it; 2)

Performing log transformation mitigates the heteroskedasticity present on the conditional distribution of the outcome variable; 3) Past literature, starting with Lederman (1956), suggests that alcohol consumption follows a log normal distribution; and 4) The interpretation from a log transformed model is comparable to that of the finite mixture model, which is discussed in the next section. After the log transformation, the coefficients can be interpreted as semi-elasticities. Given that the respondent is a current drinker, the drinking behavior is first modeled by using OLS:

$$\log(A_{ist}) = \delta_1 + \delta_2 \mathrm{Pc}_{st} + \delta_3 \mathrm{Post.MSA} * \mathrm{Pc}_{st} + \delta_4 \mathrm{Pa}_{st} + \delta_5 \mathrm{B}_{st} + \delta_6 \mathrm{X}_{ist} + \delta_7 \mathrm{s}_s + \delta_8 \mathrm{y}_t + \mathrm{e}_{ist}, \quad (5)$$

where A_{ist} is the number of drinks consumed by an individual per month and $Post.MSA * Pc_{st}$ is the interaction term between the post-MSA period and cigarette prices. The coefficient on the interaction term outlined above will indicate if higher cigarette prices following the MSA altered the relationship between cigarettes and alcohol use. The net effect of higher cigarette prices after the MSA is the sum of the coefficients on cigarette price (δ_2) and the interaction term (δ_3).[38] The other variables are similar to those of equation (3). The coefficient on cigarette price can be interpreted as semi-elasticity. For both the linear probability model and OLS, robust standard errors to functional form misspecification are estimated. To control for the within cluster correlation, standard errors are clustered at the state level.

The effect of higher cigarette prices before and after the MSA can be better explained by using Figures 6a and 6b. If the interaction term ($\mathrm{Post.MSA} * \mathrm{Pc}_{ts}$) is not included in the model and a dummy indicating the post-MSA period is added instead of the year dummies for simplicity

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[38] Using a general functional form $F(.)$, $E[(log(Alcohol|X)]$ can be written as $E[(log(Alcohol|X)] = F\,(\delta_1 + \delta_2 Pc_{st} + \delta_3 Post.MSA * Pc_{st} + \delta_4 Pa_{st} + \delta_5 B_{st} + \delta_6 D_{st} + \delta_7 X_{ist} + \delta_8 y_t)$. Letting $v = (\delta_1 + \delta_2 Pc_{st} + \delta_3 Post.MSA * Pc_{st} + \delta_4 Pa_{st} + \delta_5 B_{st} + \delta_6 D_{st} + \delta_7 X_{ist} + \delta_8 y_t)$, the marginal effect of cigarette price on the conditional expected value is $\frac{\partial E[(\log(Alcohol|X)]}{\partial cigarette\ price} = \frac{dF}{dv}\frac{\partial v}{\partial cigarette\ price} = \frac{dF}{dv}(\delta_2 + \delta_3 Post.MSA)$. In a linear model, $\frac{dF}{dv} = 1$, and the marginal effect is simply $(\delta_2 + \delta_3 Post.MSA)$. This leads to a marginal effect of $(\delta_2 + \delta_3)$ in the post-MSA period.

(Post MSA=1), then the effect of higher cigarette prices on $E(\log(Alcohol|X))$ is the same before and after the MSA. As shown in Figure 6a, the difference between the conditional expected value of $\log(Alcohol)$ between the pre-and post-MSA period is fully captured by the difference in the intercept estimated by the coefficient on the post-MSA dummy. As hypothesized, the effect of higher cigarette prices on $E(\log(Alcohol|X))$ after the MSA could be different than the effect before the MSA. Such hypothesis can be tested by adding an interaction term as presented in equation (5). The model will now allow both the intercept and the marginal effect (slope) to vary for the periods before and after the MSA. As depicted by Figure 6b, the marginal effect of cigarette prices for the period before the MSA is given by δ_2, whereas after the MSA (when $\text{Post. MSA} = 1$) it is $\delta_2 + \delta_3$. However, the marginal effect of higher cigarette prices on $E(\log(Alcohol|X))$ is constant over the entire range of cigarette prices.

Including state and year fixed effects in the model can be viewed as an extension of the difference-in-differences frameworks that allow for multiple treatment and control groups and multiple time periods rather than having a setting of two groups (control and treatment) and two periods (pre-and- post) (Wooldrige, 2001). The unbiased estimates of higher cigarette prices in this setting require that there exist no contemporaneous state-level trends that are correlated with increases in cigarette prices and alcohol consumption. To account for alcohol control laws that could potentially affect the drinking pattern, state-level keg control policies, laws applicable to selling alcoholic beverages, and retail sale laws are included in the specification. The increase in cigarette prices mainly occurred during an era of widespread anti-smoking sentiment. Concurrently, policies regarding smoking bans in certain places (restaurants, bars, and workplaces) and restrictions were being introduced. To analyze the effect of such possible confounders, the alternate models control for the states' smoke-free air laws and anti-smoking sentiments.[39]

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[39] A detailed discussion is provided in Section VII, which discusses potential threats regarding identification.

To evaluate differential effects of higher cigarette prices on alcohol consumption, equation (3) is estimated by using two different econometric methods: 1) Quantile regression and 2) Finite mixture model (FMM). These methods are both implemented as they each serve specific purposes. To analyze whether MSA ifself affected alcohol consumption among young adults, I use Regression Discontinuity design. The reasoning behind the selection of econometric methods and a brief description of the methods are given below.

4A. Quantile Regression

The estimates of equation (5) focus on conditional means. A quantile regression method is used to allow the effects of cigarette prices to vary across the distribution of the dependent variable The τ^{th} conditional quantile function for drinking outcome given that a person drinks can be specified as follows:

$$\log(A_{ist}) = \delta_{1\tau} + \delta_{2\tau}\mathrm{Pc_{st}} + \delta_{3\tau}\mathrm{Post.MSA} * \mathrm{Pc_{st}} + \delta_{4\tau}\mathrm{Pa_{st}} + \delta_{5\tau}\mathrm{B_{st}} + \delta_{6\tau}\mathrm{D_{st}} + \delta_{7\tau}\mathrm{X_{ist}} + \delta_{8\tau}\mathrm{y_t} + \mathrm{e_{ist}}, \quad (6)$$

where the coefficients of interest are $\delta_{2\tau}$ and $\delta_{3\tau}$. The interpretation of these coefficients is similar to that of equation (5), except that now they pertain to the τ^{th} conditional quantile instead of the conditional mean. For the coefficients pertaining to quantile regression, bootstrapped standard errors clustered at the state level are estimated from 199 replications. It should be noted that the estimates of elasticities and semi-elasticities might be misleading in the context of quantile regression analysis. A similar magnitude of semi-elasticities across the quantiles conceals the effects at the higher quantiles by mitigation. In the context of this study, the interest is the effect of higher cigarette prices on the number of drinks consumed. Another advantage of quantile regression is the relevance of equivariance property (Cameron and Trivedi, 2009).[40]

4B. Regression Discontinuity Design (RDD)

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[40] The equivariance property defines that if $Q_\tau(lny|x) = X`\beta$, then $Q_\tau(y|x) = \exp(lny|x) = \exp(X`\beta)$. The marginal effect is given as, $\frac{\partial Q_\tau(y|x)}{\partial x_j}$ = $\exp(x`\beta_\tau)\beta_{\tau j}$. This can be obtained by predicting the conditional quantiles and multiplying the result by estimates of respective coefficients.

As a form of non-experimental design, regression discontinuity (RD) can be used to evaluate the effects of the MSA on alcohol consumption. The RD analysis can be applied in this particular study by considering the year the MSA was passed (1998) as a threshold or a cut-off point, and the years before and after the passing of the MSA as a rating variable. By properly controlling for the trend in the rating variable, any unobserved differences between the treatment and comparison groups can be accounted for. The use of RD design in this scenario meets the required conditions: 1) The rating variable is not influenced or caused by the MSA; and 2) The assignment of treatment is likely to be exogenous — in other words, it is highly unlikely that the timing of the enactment of the MSA is dependent on the trend in alcohol consumption.

In the RD setting, we can consider individuals surveyed in the years before November 1998 as the ones not exposed to treatment and those interviewed after November 1998 as treated, (November 1998 is the cut-off point). We only observe $E[Y_i(1)|X]$ to the right of the cut-off point and $E[Y_i(0)|X]$ to the left of the cut-off, where X here is a rating variable (e.g., quarters away from the passing of the MSA). The average treatment effect (ATE) at the cut-off point can be written as:

$$ATE = \lim_{e\to 0} E[Y_i|X_i = c + e] - \lim_{e\leftarrow 0} E[Y_i|X_i = c + e],$$

which equals to $E[Y_i(1) - Y_i(0)|X = c]$. The idea here is to use the average alcohol consumption of people before 1998 as a counterfactual (denied the treatment) and compare it to people just above the cut-off period (those who received the treatment). To concentrate at the sharp RD design, I focus on individuals who are both smokers and drinkers and whose alcohol consumption will be affected by the MSA. In such a case, one can think of treatment switching from 0 to 1 right after the passing of the MSA.

When considering the question of whether the MSA itself affected the alcohol consumption of young adults, RD provides an ideal design. By focusing right around the threshold (passage of the MSA in 1998), the RD approach yields a consistent estimate of the treatment effect (Lee and Lemieux, 2011). The reason is that people just before and after the threshold point are essentially affected by the same unobserved factors influencing alcohol consumption, with the exception that people surveyed after the passage of the MSA are exposed to treatment. Such a design can be regarded as a locally randomized experiment, given that the period of the MSA is not systematically correlated to alcohol consumption. Lee and Lemieux (2008) suggest that the presence of local randomization is testable by inspecting whether baseline covariates are balanced. I therefore test whether baseline characteristics experience discontinuity around the MSA period.

To evaluate the effect of the MSA on alcohol consumption among current drinkers, I specifically estimate the following equation:

$$\log(A_{ist}) = \delta_1 + \delta_2 \, Period_i + \delta_3 \, f(\,.\,) + \delta_4 \, X_{ist} + u_{ist,} \qquad (7)$$

where the dependent variable is the log of monthly alcohol consumption for individual i in state s at time t; Period is a dummy variable indicating whether a respondent belongs to the post-MSA period; $f(.)$ is a smooth function that captures the underlying relationship between the year and alcohol consumption, and X_{ist} represents other individual-level characteristics. The term u_{ist} represents the unobservable factors of the log of alcohol consumption. The parameter of interest is δ_2 — the effect of the MSA on alcohol consumption.

I first use a parametric approach to estimate the parameter δ_2. This strategy, known as a global strategy, uses every observation in the sample to model the outcome variable as a function of treatment and the rating variables. Selecting the proper functional form representing $f(\,.\,)$ is one of the greatest challenges of parametric regression design. The consequence of using an incorrect functional form is even more serious in RD design (Lee and Lemieux, 2011). A variety of functional forms — linear, linear interaction with treatment variable, quadratic, and quadratic with interaction — are tested to find the one that fits the data. Specifications with and without the covariates are estimated. One disadvantage of including polynomials of various degrees is that the regression uses all observations, including those far away from the cut-off point.

The nonparametric RD design concentrates on applying the insight of Thistlehwaite and Campbell (1960) to a narrower window around the cut-off point, after which, the estimation can be performed by using a standard linear regression approach. This process is also known as a local linear regression. I use a triangular kernel for the purpose of estimation as triangular kernels perform better when estimating local linear regressions at the boundary (Fan and Gijbels, 1996). The nonparametric approach leaves us with the question of how to choose the bandwidth.

Choosing a bandwidth requires finding an optimal balance between precision and bias — a large bandwidth improves precision, but it increases bias; whereas a small bandwidth sacrifices precision for decreased bias. I use the cross-validation approach to determine the optimal bandwidth. First, a regression is run with observation i omitted and the regression estimates are used to predict the value of Y at $X = X_i$. This process is repeated for each and every observation i omitted and the entire set of predicted values are obtained. The optimal bandwidth is selected by minimizing the mean square of the difference between the actual and predicted value of Y_i (an observation that is omitted). This can be given by the equation $CV_Y(h) = \frac{1}{N}\sum_{i=1}^{N}(Y_i - \hat{Y}(X_i))^2$. For optimal bandwidth selection, the cross validation function given in preceding line is minimized over h. Various bandwidths are tested for robustness, including varieties of functional forms.

4C. Finite Mixture Model (FMM)

A finite mixture model (FMM) postulates that a random variable, in this case the observed number of drinks consumed, is drawn from a population, which is the additive mixture of *C* distinct subpopulations in proportions $\pi_1, \ldots, \pi_c$. The mixture density for observation *i*, *i* = *1, …., n* is given as

$$f(A_i|\Theta,\pi) = \sum_{j=1}^{C} \pi_j f_j(A_i|\Theta_j), \ where\ 0 \le \pi_j \le 1, and\ \ \sum_{j=1}^{C} \pi_j = 1, \quad (8)$$

where $f_j(A_i|\Theta_j)$ is the density of j^{th} component or subpopulation and π_j is the respective mixing probability. The mixture density is the weighted average of mixing probabilities and respective density functions where the mixing probabilities (π_j) are constant across observations. The mixing probabilities are estimated along with the other parameters of the model by using a maximum likelihood estimation (MLE). Prior to this point, the classes are latent. The mixing variables do not require any distributional assumption for estimation, so the finite mixture model can be viewed as a semi-parametric approach to a flexible and parsimonious modeling of the data (Deb and Trivedi, 1999). The likelihood function for the constant probability model is:

$$L(\Theta,\pi) = \prod_i \sum_{j=1}^{C} \pi_j f_j(A_i|\Theta_j). \quad (9)$$

The likelihood function demonstrated by equation (8) assumes that the analyst has no information regarding class membership. However, imperfect information exists in the sample, which can help predict class membership. In light of such information, the prior probability (π) is modeled as a function of other observable characteristics by using a logit probability model. The prior probability function can be written as

$$\pi_{ij} = logit(Z_i|\Omega),\ \ where\ 0 \le \pi_j \le 1, and\ \sum_{j=1}^{C} \pi_{ij} = 1, \quad (10)$$

where, Z_i is a vector of observables associated to an individual `i'. The prior probability now varies across observations. The likelihood of the variant probability model can be written as

$$L(\Theta,\pi) = \prod_i \sum_{j=1}^{C} \pi_{ij} f_j(A_i|\Theta_j). \quad (11)$$

This facilitates the calculation of the posterior probability of being in each type by using the Bayes' Theorem, given as

$$P(A_i\ \epsilon\ k|\Theta, A_i) = \frac{\pi_k f_k(D_i|\Theta_k)}{\sum_{j=1}^{C} \pi_j f_j(D_i|\Theta_j)}\ \ , for\ k = 1, 2, \dots\dots, C.) \quad (12)$$

The two-component constant probability model is first estimated by using a negative binomial with quadratic variance as the parametric distribution. A negative binomial is chosen as it is the most flexible and general way of modeling the pattern of overdispersion among those available in the statistical literature for parametric models of count data (Cameron and Trivedi, 2009).[41] The initial estimates of π are then used to re-estimate the two-component model by letting the prior probabilities depend on age, gender, race, marital status, education, and income. Robust standard errors clustered at the state level are presented.

FMM has been applied in a variety of fields requiring statistical modeling of the data including economics (Heckman and Singer, 1984; Wedel et al., 1993; Deb and Trivedi., 1997; and Ayyagari et al., 2011). The use of the finite mixture model is favorable for the purpose of this study as it supports the notion of heterogeneity by forming a small number of latent classes, which can be referred as “type.” For example, in analyzing the demand for health care, frequent and non-frequent users of heath care can be categorized as two different types (Deb and Trivedi, 1997). These latent classes are not merely identified by breaking down the sample according to the observed characteristics such as age, sex, and race. FMM is generally attractive if the mixture components have a natural interpretation, though this is not essential, as an example, note frequent versus non-frequent drinkers (Ayyagari et al., 2011; and Deb and Trivedi., 1999).

5. Results

Figure 4 displays the trend in average drinks consumed per month for currently drinking 18-to-24-year old along with cigarette prices. Figure 5 further plots average monthly drinks consumed by who both smoke and drink. The number of drinks consumed per month is higher in Figure 5 than in Figure 4 throughout the entire years of the study, confirming that smokers are likely to drink more than non-smokers. Both Figures 4 and 5 show that the rise in the average monthly consumption of drinks coincides with the timing of the tobacco settlement. The 20th and 80th quantiles of the number of drinks consumed monthly by smokers and current drinkers is

[41] FMM with Poisson components failed to converge.

plotted in Figure 1B. The solid line represents the 20th quantile, whereas the dotted line pertains to the 80th quantile. Figure 1B indicates that after the settlement the trend in drinks consumed for the 80th quantile increased dramatically from 40 drinks per month in 1997 to 60 drinks per month in 2003, whereas no such fluctuation exists for the 20th quantile. These figures provide suggestive evidence that higher cigarette prices after the MSA increased alcohol intake among 18-to-24-year olds, especially at the higher quantile of drinks consumed. However, the figures do not account for other factors that could potentially influence alcohol consumption.

5A. Did Higher Cigarette Prices Change the Relationship Between Cigarettes and Alcohol?— Results from Two-Part Model

Table 2 presents the results obtained from using a two-part model for 18-to-24-year olds. The first column corresponds to the results from the linear probability model, the second presents the results from estimating equation (5) using OLS, and the remaining columns pertain to quantile estimates.

Results from Table 2 indicate that higher cigarette prices do not affect one's decision to drink. Among drinkers, the OLS findings suggest that higher cigarette prices before the MSA period are associated with a reduction in monthly alcohol consumption by 2.94 percent, though the coefficient is imprecisely estimated. The coefficient on the interaction term is positive and significant at a 5 percent level, demonstrating the apparent differences in slope change between the pre-and post-MSA period. This indicates that the average effect of higher cigarette prices on alcohol consumption after the MSA was different from the effect before the MSA. The net effect of higher cigarette prices in the post-MSA period is given in the bottom section of Table 2. The OLS estimate suggests that a $1 increase in the price of pack of cigarettes is associated with an increase in monthly alcohol consumption by 4.36 percent. The F-statistic for the null hypothesis that the coefficients on cigarette prices and the interaction term jointly are equal to zero rejects the null.[42] This suggests that the effect of higher cigarette prices after the MSA is significant at a 1 percent level. The effects of higher cigarette prices on alcohol consumption before and after the MSA can be further clarified by referring to Figure 6. The slope representing the effect of higher cigarette prices on alcohol consumption is positive for the post-MSA era; whereas, the effect is negative for the pre-MSA era. The difference between the slopes of the dotted line and the solid line is captured by the coefficient on the interaction term. In summary, the results support the weak complementarity of cigarettes and alcohol consumption before the MSA period, though the coefficients are imprecisely estimated. After the MSA, the evidence indicates that higher cigarette prices led individuals to substitute alcohol for cigarettes.

The coefficients on the interaction term estimated by quantile regression indicate that higher cigarette prices after the MSA changed the link between cigarettes and alcohol for light and moderate drinkers. Given the association between smoking and drinking, heavy smokers are likely to fall in the higher conditional quantiles of alcohol consumption. Similarly, the lower conditional quantiles are likely to have many nonsmokers or light smokers. Sizable increases in cigarette prices after the MSA seem to have influenced light smokers to quit and discouraged potential smokers from initiating smoking.[43] This mechanism will increase the disposable income of consumers given that light smokers have an elastic demand. These individuals might have increased their alcohol intake due to increases in their disposable income as alcohol is a normal good.

The net effect of higher cigarette prices after the MSA, demonstrated in the bottom of Table 2, indicates the occurrence of substitution across all reported conditional quantiles,

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[42] The null hypothesis being tested is $H_0 : \mathrm{R}\delta - \mathrm{q} = 0$ against the alternative $H_1 : \mathrm{R}\delta - \mathrm{q} \neq 0$, where $R = \begin{vmatrix} 0 & 1 & 0 \ldots & 0 \\ 0 & 0 & 1 \ldots & 0 \end{vmatrix}$, $\delta = \begin{bmatrix} \delta_1 \\ \delta_2 \\ . \\ . \\ \delta_8 \end{bmatrix}$, and $q = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$. Two linear restrictions from equation (5) are being tested: $\delta_2 = 0$ and $\delta_3 = 0$.

[43] Prior literature suggests that light smokers are likely to quit in response to higher cigarette prices (Paterson et al., 2008; Coggins et al., 2009; and Adda and Cornaglia, 2012).

including amongst relatively heavy drinkers. For instance, a $1 increase in a pack of cigarettes is associated with an increase in monthly alcohol consumption by 4.6 percent and 5.25 percent at the 20th and 30th conditional quantiles, respectively, and the estimates are statistically significant at a 5 percent and 1 percent levels, respectively. Similarly, a $1 increase in the price of a pack of cigarettes is associated with an increase in alcohol consumption by 3.77 percent and 4.11 percent at the 70th and 80th conditional quantiles, respectively, and the coefficients are both significant at a 5 percent level.

The issue of sample selection, which might arise from using the two-part model, needs to be discussed. The evidence of substitution from cigarettes to alcohol seen in the second-part model in Table 2 could potentially be driven by people who regard cigarettes and alcohol as complements dropping out of the sample before entering the second-part model. In other words, higher cigarette prices influence the participation decision of individuals by deterring them from drinking when they otherwise would have participated in drinking in the absence of a rise in cigarette prices. If the results of the second-part model are driven due to selection, the effect of cigarette prices after the MSA should be negative in the first part model, suggesting that a rise in cigarette prices reduce alcohol intake. This would be suggestive of young adults who regard cigarettes and alcohol as complements dropping out of the sample used in the second part. However, as mentioned in the preceding paragraph, a rise in cigarette prices did not affect drinking participation.

If increases in cigarette prices after the MSA led to increases in alcohol consumption among the drinkers, such an effect would be stronger among the current drinkers who also reported having smoked cigarettes. One way through which non-smokers' alcohol consumption is likely to be affected as a result of higher cigarette prices is by discouraging those who would have otherwise smoked if cigarette prices had not increased. Such individuals may compensate their desire to smoke by increasing their alcohol intake. However, the youngest age cohort in my sample is 18-year olds; hence the majority of individuals in my sample are likely to have passed the smoking initiation age. The National Survey on Drug Use and Health (NSDUH) estimates that more than 80 percent of all adults smoke before age 18 and 90 percent do so before turning 20 (SAMSHA, 2007).

Table 3 shows the results once the sample is restricted to current drinkers who reported having smoked cigarettes. As anticipated, the effect of increases in cigarette prices on alcohol consumption is stronger at the conditional mean and for the reported quantiles when compared to the findings in Table 2. The coefficient on cigarette price, which reflects the effect of higher cigarette prices before the MSA, is negative across the reported conditional quantiles — though statistically insignificant at the conventional levels. The coefficients on the interaction term between the post-MSA period and cigarette prices are positive and significant at the conventional levels, at the conditional mean, and across the reported conditional quantiles. This suggests that higher cigarette prices changed the relationship between cigarette and alcohol use for the drinkers and smokers by adding substitutability among cigarettes and alcohol in the post-MSA period. The effect of increases in cigarette prices on alcohol consumption after the MSA is reported in the bottom of Table 3. The estimates show that increases in cigarette prices led individuals to substitute cigarettes for alcohol throughout the reported conditional quantiles. The joint F-statistic for the coefficients of cigarette prices and the interaction term suggest that the effect of higher cigarette prices after the MSA is significant at a 1 percent level at the conditional means and for the reported quantiles (except for the 40^{th} quantile, which is significant at a 5 percent level).

The sample that is used to obtain the results in Table 3 contains both cigarettes and alcohol in their consumption bundle. Following economic theory, income effect due to increases in cigarette prices would decrease the consumption of both cigarettes and alcohol for these individuals. However, due to increases in cigarette prices, alcohol consumption increases because alcohol is relatively cheaper in the bundle given that the price of alcohol remains unchanged. Hence, this may lead a consumer to reduce the portion of his/her budget that is spent on cigarettes and to increase spending on alcohol, thus creating a substitution effect. The findings of Table 3 suggest that the substitution effect dominates the income effect, as the coefficients on cigarette prices after the MSA are positive, thus suggesting that consumers substituted alcohol for cigarettes at the conditional means and the reported quantiles.

It should be noted that the effect of increases in cigarette prices after the MSA on alcohol consumption is concentrated at the higher conditional quantiles in terms of actual number of drinks consumed. For instance, the coefficient indicates that a $1 increase in a pack of cigarettes is associated with an increase in alcohol consumption by 10 percent and 7 percent at the 20^{th} and 70^{th} conditional quantiles respectively. However, the predicted number of drinks consumed for the 20th and 70th conditional quantiles are 5 and 28.22 drinks per month, respectively.

In summary, the findings from a quantile regression analysis indicate that higher cigarette prices led young adults to substitute alcohol for cigarettes in the post-MSA period; however, the economic relationship between the two substances was weak in the pre-MSA period. Moreover, the effect of cigarette prices on alcohol consumption is different in the post-MSA period compared to the pre-MSA period. This indicates that increases in cigarette prices following the MSA altered consumers' ongoing tastes between cigarettes and alcohol, making alcohol more substitutable for cigarettes.

5B. Did MSA Increase Alcohol Consumption? Results from RDD

First, I begin my analysis graphically by focusing on the period of the MSA passage in 1998. Figure 7a shows a scatter plot and fitted local polynomial lines of the log of mean drinks consumed for current drinkers and those reported having smoked cigarettes by quarters relative to the MSA period.[44] Before the MSA, alcohol consumption demonstrates a declining trend. The

[44] A quarter is chosen as an appropriate selection of bin width according to the F-test based on the idea that if bin width is too wide, shrinking the bin size can provide a better fit to the data. First, I regress the log of drinks consumed per month on a set of quarterly indicators. Second, I perform a similar regression with an exception that the indicator variables represent two month period. The F-test is performed to test the null hypothesis that the bin width of a quarter is oversmoothing the data. The F-statistic is statistically

graph illustrates discontinuity at the MSA period. Soon after the MSA, alcohol consumption portrays an increasing trend for at least for twenty quarters, after which the trend subsides. The decrease in trend starting from 2003 coincides with a reduction in the federal blood alcohol concentration (BAC) law to 0.08 percent and with many states implementing smoking bans in bars. Figure 7b shows the trend in main baseline covariates, which can affect alcohol consumption. Cigarette prices experience a small discontinuity right after 1998; however, the gap extends in the year 2001, suggesting that increases in cigarette prices occurred gradually after the passing of the MSA. Other covariates show no sign of discontinuity, which satisfies an assumption of a RD design — that the baseline covariates should not experience discontinuity at the threshold.

Table 4 shows the results from a global RD design; Panel A excludes covariates and Panel B includes covariates. Model (1) includes linear control of the rating variable (quarters away from the MSA period); model (2) adds the interaction term between the rating variable and post-MSA dummy; model (3) adds the quadratic term of the rating variable; and model (4) includes the interaction between the quadratic term and post-MSA period.

The results across the columns show that the MSA increased alcohol consumption among drinkers who reported having smoked cigarettes. When controlling for the covariates (Panel B), which includes the state fixed effects, model (1) suggests that the passing of the MSA increased alcohol consumption by 19.6 percent and is significant at a 1 percent level. A coefficient pertaining to model (4), Panel B, suggests that the MSA led to an increase in alcohol consumption by 8.7 percent and the coefficient is significant at a 10 percent level. To select the preferred model from a global strategy, I plot the log of the predicted monthly number of drinks consumed per quarter along with the running variable (quarters away from the MSA period). The plots pertaining to each model from Panel B of Table 4 is presented in Figure 7c. Visually,

insignificant at the conventional levels; thus, we fail to reject that the bin width of a quarter is oversmoothing the data.

model (4) best predicts the actual log of monthly drinks, shown in the bottom row of Figure 7c. After conducting an F-test, I fail to reject the null hypothesis that model (4) is not underspecified at a 5 percent level when comparing model (4) with an alternative model, which additionally includes a third degree polynomial of the running variable. In summary, using both the graphical approach and F-test approach, I view model (4) as the preferred model, which suggests that the MSA led to an increase in alcohol consumption by 8.7 percent among the drinkers who are current smokers.

One main drawback of a global strategy is that it uses all the observations, including the ones far away from the MSA period. To utilize observations closer to the quarter in which the MSA was enacted, I estimate local linear regressions before and after the MSA by using a triangular kernel (Ming-Yen Cheng, Jianqing Fan, and J. S. Marron, 1997). The choice of bandwidth is made by using a cross-validation approach. In addition, I estimate OLS models that include covariates with several bandwidth choices. This is a simple local linear regression where all the observations are equally weighted by a rectangular kernel regardless of the distance from the MSA quarter. The only difference between the two different types of kernels is that a triangular kernel places more weight on observations closer to the cut-off point.

Table 5 shows the results from the local linear regression, including the OLS regression with various bandwidths. Column (1) reports the difference in local linear regression estimates before and after the MSA period. The bandwidth of 12.4 quarters away from the MSA is used, which is obtained from a cross validation method. The coefficient suggests that alcohol consumption increased by 25.5 percent after the MSA and is significant at a 1 percent level. Columns (2)-(5) presents estimates from OLS with controls for quarters away from the MSA as well as quarters away from the MSA interacted with the post-MSA dummy. The interaction term allows the trend of alcohol consumption to vary before and after the MSA period. Using a 10 quarter window, the results are similar to the results obtained from the local linear regression in column (1). Column (3) includes a full set of covariates, which leaves the results unchanged; the magnitude is similar in size (0.29 and 0.31). Columns (4) and (5) uses wider windows (25 quarters away) from the MSA. The magnitude shrinks; however, the main results remain unchanged, which suggests that the MSA led to an increase in alcohol consumption.

5C. Who Responded to Higher Cigarette Prices? — Finite Mixture Model (FMM) Results

Table 6 provides results from the two component finite mixture model for the period after the MSA (1999 to 2008). The first two columns correspond to 18-to-24-year olds. In order to check whether the effects of higher cigarette prices on alcohol demand vary according to the underage individuals and those over 21, the two component model is re-estimated by dividing the sample into two groups: 1)Eighteen to 20 year olds; and 2) Those over 21. Such a division of the sample according to age groups is not arbitrary, as underage individuals in my sample can legally purchase a pack of cigarettes but cannot legally buy alcoholic beverages. Underage individuals in this regard face an additional cost while purchasing alcoholic beverages. A-priori, the effect should be pronounced among individuals who are over 21, as the switching cost from cigarettes to alcohol is lower for this group compared to 18-to-20-year olds.

5C.1. The Effect of Cigarette Prices on Alcohol Demand (FMM Model)

Results estimated by the two component finite mixture model in Table 6 produce distinct coefficients on cigarette prices for each component. Focusing on the estimates corresponding to 18-to-24- year olds, the coefficient on cigarette prices suggests that increases in cigarette prices are associated with an increase in alcohol consumption among both components. The predicted number of drinks presented in the bottom of Table 6 suggests that individuals in component 1 on average consume about 3 drinks per month and 53 percent of the sample is likely to fall in component 1. In contrast, component 2 on average consumes 23 drinks per month and consists of 47 percent of the sample. Using a finite mixture model creates a sharp distinction between the two groups in regard to the level of alcohol consumption and hence allows investigating the differential effect of higher cigarette prices on alcohol demand. The result for 18-to-24-year olds indicates that individuals in component 2 reacted to higher cigarette prices by increasing their alcohol consumption. For instance, a $1 increase in a pack of cigarettes is associated with an increase in alcohol consumption by 6.59 percent.

For 18-to-20-year olds, there is a sharp distinction between component 1 and 2 in terms of the predicted number of drinks consumed per month. Predicted monthly drinks are 2 and 24 drinks for component 1 and 2, respectively. However, estimates of the cigarette price coefficient are statistically insignificant for both components. This provides no statistical evidence that higher cigarette prices affected the alcohol consumption of underage individuals. For the cohort of 21-to-24-year olds, relatively frequent drinkers are more responsive to higher cigarette prices. The coefficient on cigarette prices for component 2 indicates that a $1 increase in the price of cigarettes is associated with an increase in monthly drinks consumed by 7.81 percent and the coefficient is statistically significant at a 5 percent level. The average number of monthly drinks consumed in the responsive group is 22.5, and 48 percent of 21-to-24-year olds are likely to fall in this group. The results for 18-to-20 and 21-to-24-year olds are consistent with the hypothesis that the switching costs for 21-to-24-year olds are lower than for the younger cohort.

5C.2. Prior Probabilities

Table 7 shows the results for a basic set of observable variables used to classify observations into latent components. Findings from Table 7 indicate that younger, married, more educated, and non-white are more likely to fall into the first component for all three age windows. Income coefficients for 21-to-24- year olds show that individuals with a household income over 50,000 are less likely to fall into component 1. This is consistent with the prior findings of a positive correlation between income and drinks consumed.

5C.3. Posterior Probability:

Table 8 shows the descriptive analysis of the posterior probabilities obtained for component 2 pertaining to 18-to-24 and 21-to-24-year olds — groups that are responsive to higher cigarette prices. The posterior probabilities are regressed on the set of observable characteristics. The main variables of interest are current smokers and binge drinkers. The responsive component for both the 18-to-24 and 21-to 24- year old cohorts are more likely to include smokers and binge drinkers. Similar to the results from quantile regression, smokers may have reduced their cigarette consumption due to increases in cigarette prices and compensated for such a reduction by increasing alcohol consumption. Put together, results from the finite mixture model point out the unintended consequences of increases in cigarette prices as evidence suggests that binge drinkers react to increases in cigarette prices by increasing their alcohol intake. Since externalities related to alcohol consumption are concentrated towards binge drinking, this issue is a potential concern when raising cigarette taxes or initiating litigation that could increase cigarette prices.

6. Cigarette Prices and Driving Fatalities

Until now, the findings indicate that higher cigarette prices after the MSA increased alcohol consumption among light, moderate, and heavy drinkers. If increases in cigarette prices lead heavy and binge drinkers to substitute alcohol for cigarettes as suggested by the results, it is likely that higher cigarette prices may explain some of the variation in the trend of alcohol-related driving fatalities among 18-to-24- year olds. In other words, if higher cigarette prices lead to an increase in driving fatalities, it has to be through an increase in alcohol consumption. To analyze the effect of higher cigarette prices on driving fatalities, I estimate the following regression:

$$Y_{st} = \alpha_1 + \alpha_2 rcigprice_{st} + \alpha_3 X_{st} + \mathrm{y_t} + s_s + e_{st} \qquad (12)$$

The dependent variable Y_{st}, takes three different forms: 1) Population at risk of alcohol-related driving fatalities (alcohol related fatalities/population of 18-to-24-year olds); 2) Log of alcohol-related fatal accidents; and 3) Count of alcohol-related fatal accidents.[45] X_{st} is a vector of control variables accounted for in the model, such as real beer taxes, smoking bans in bars, an indicator representing if the state has adapted the blood alcohol concentration level law of 0.08, log of per

[45] These specifications have been used in the previous literature. Please see Adams and Cotti (2012).

capita income, unemployment rate, log of the state-level population to account for congestion, and state minimum wage. To capture the likelihood of being involved in an accident due to across-state differences in speed limits, gas prices, highway construction, weather patterns, and other state-specific idiosyncrasies, X_{st} also includes the log of driving fatalities not associated with alcohol consumption.[46] The specification further includes state fixed effects (s_s) and year fixed effects ($\mathrm{y_t}$). The data for fatal accidents are obtained from the Fatality Analysis Reporting System (FARS) of the National Highway Traffic Safety Administration (NHTSA). A detailed discussion regarding the data use is provided in Appendix C.

Table 9 shows the results after estimating equation (11) for the years 1996 to 2003. The year is limited to 2003 for three reasons. First, as shown in Figure 10, many states started implementing smoking bans in bars after 2003. The passage of smoke-free air laws and higher cigarette taxes most likely share the same data generating process, which could potentially lead to an issue of multicollinearity. Focusing in the pre-2004 period facilitates isolating the effect of smoking bans in bars with that of increases in cigarette prices. [47] Second, the deadline for lowering the blood alcohol content (BAC) level from 0.10 to 0.08 percent was on October 1, 2003. Limiting the year to 2003 provides a cleaner framework to isolate the effect of higher cigarette prices from the effect of the change in the BAC level.[48] Third, cigarette prices faced substantial increases before 2004 as payment obligations were shifted forward to the consumers by the settling companies; whereas, after 2004 increases were due mainly to higher taxes. Hence, the years 1996 to 2003 provides a base with which to analyze the immediate effect of higher cigarette prices following the MSA on alcohol-related driving fatalities.

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[46] Such an approach is applied by Adams and Cotti (2012).

[47] Adams and Cotti (2008) conclude that a smoking ban in bars led to an increase in fatal accidents involving alcohol. By 2003, only California had enacted smoking bans in bars.

[48] Although almost all states complied with the federal limit by October 1, 2003, the rigor of application of the law differs across states. In such a case, year indicators cannot fully absorb the effect of a 0.08 BAC level. If the rigor of application of the BAC law is correlated with cigarette prices, then estimates on cigarette prices will be biased.

Panel A in Table 9 relates to the fatalities related to alcohol consumption. The first column uses a population at risk of alcohol-related driving fatalities as the dependent variable, where the rate is calculated as the number of alcohol-related driving fatalities divided by the population of 18-to-24-year olds for a given state and time period. The second and third column uses the log of the count of alcohol-related fatalities and the actual count of alcohol-related fatalities, respectively. The coefficients in column (2) are reported after multiplying the obtained coefficients by 100. The results show that higher cigarette prices are positively associated with an increase in alcohol-related fatalities. For instance, the coefficient on cigarette price in column (1) show that a $1 increase in a pack of cigarettes is associated with an increase in the risk of alcohol-related fatalities by 0.0013 percent. The formation of a dependent variable used in column (1) is problematic if cigarette prices are an increasing function of the population of 18-to- 24-year olds. As one of the goals of the MSA was to decrease smoking rates among young adults, the construction of the dependent variable given in column (1) may understate the effect of higher cigarette prices on driving fatalities. The coefficients on the cigarette price of columns (2) and (3) both indicate that a $1 increase in a pack of cigarettes is associated with an increase in driving fatalities by 16 percent and 10 percent respectively. The results are statistically significant at conventional levels.

To show that the findings are not spuriously driven, the effect of higher cigarette prices on driving fatalities not related to alcohol is estimated (shown in Panel B of Table 9). There is no possible reason to believe that higher cigarette prices would increase driving fatalities not related to alcohol.[49] Any result suggesting that higher cigarette prices are related to an increase in driving fatalities unrelated to alcohol could indicate that other factors, such as omitted variables and measurement issues, are driving the findings in Panel A. However, the coefficient on the cigarette price in column (1) in Panel B is small and close to zero. Those of columns (2) and (3) are

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[49] If anything, higher cigarette prices may reduce driving fatalities due to an increase in concentration while driving.

negative, suggesting that higher cigarette prices are instead negatively associated with alcohol-related driving fatalities. Such an effect can be driven by an increase in driving concentration from people who have reduced their smoking rate due to higher cigarette prices. This provides further evidence that higher cigarette prices after the MSA induced drinking among young adults.

7. Anti-smoking Sentiments and Alcohol Consumption (Direct Versus Indirect Channel)

Higher cigarette prices after the MSA can lead to substitution of alcohol for cigarette by explicitly creating a sense of anti-smoking sentiment. For instance, substantial increases in cigarette prices following the MSA could potentially send a clear and visual message regarding the harm associated with smoking. This can make alcohol consumption relatively more socially-acceptable than cigarettes. To isolate such a channel, the method applied by DeCicca et al. (2006) is used to capture state anti-smoking sentiments, and regressions include control for the variable representing anti-smoking sentiments. [50]

Table 10 shows the findings, where column (1) pertains to the specification without the anti-smoking sentiments and column (2) includes the anti-smoking sentiments. The coefficients on the price of cigarettes and the interaction term between the cigarette price and post-MSA period are similar after adding the measures of anti-smoking sentiments in column (2). Once the anti-smoking sentiments are accounted for, the results can be interpreted as that being driven majorly through the monetary channel (rise in cigarette prices) rather than higher cigarette prices itself creating a sense of anti-smoking sentiment. If the effect of higher cigarette prices on alcohol consumption was working through an indirect channel, for instance by prices itself increasing anti-smoking sentiments and creating a rise in pro-drinking sentiments, including a measure of

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[50] Adapting DeCicca et al.'s (2008) strategy, I use attitudes regarding smoking in various places to measure a state's anti-smoking sentiments. The data is obtained from 1995-1996, 1998-1999, 2000-2001, 2002-2003, and 2006-2007 waves of the Current Population Survey Tobacco Use Supplement (TUS-CPS). For bars, restaurants, workplaces, and sporting events, individuals are asked if smoking should be allowed, allowed in some areas, or not allowed. Also, respondents are asked to report their smoking environment at home. I use a principal factor analysis to obtain one latent variable, which represents the anti-smoking sentiments. For each wave, the estimated factor is normalized to have a mean of zero. Estimated factors are then averaged by state and year and I linearly interpolate and extrapolate the estimated factors for the missing years as required.

anti-smoking sentiment in the model should reduce the magnitude of the coefficients on cigarette prices.

Columns (3) and (4) of Table 9 include the lag and lead of the anti-smoking sentiments. The anti-smoking sentiment in the previous period is likely to be correlated with current prices. However, it could be problematic if the rise in anti-smoking sentiment determines alcohol consumption in the future. In such a scenario, failure to account for the lag of anti-smoking sentiments will overestimate the effect of higher cigarette prices on alcohol consumption. However, the effect of higher cigarette prices on alcohol consumption shown in columns (3) and (4) are similar. Such findings indicate that the possible mechanism of higher cigarette prices propagating anti-smoking sentiments, and hence leading young adults to substitute alcohol for cigarettes, is not driving the results. This provides evidence that increase in anti-smoking sentiments may have little to contribute to the switch from cigarettes to alcohol and the effect of higher cigarette prices on alcohol consumption is majorly thus reliant on the monetary channel.

8. Evidence Regarding Potential Threats to Validity

Identification of the effect of higher cigarette prices on alcohol consumption relies on an assumption that there exists no state-level trends that are correlated to higher cigarette prices and also affects alcohol consumption. Hence, several robustness checks are conducted to test the validity of the obtained results.

8A. Smoke-Free Air Laws. During the 1990s, several states implemented Smoke-Free Air laws (SFA laws) such as smoking ban in bars, restaurants, and workplaces. An additional concern of this study is whether the empirical models are failing to account for the SFA laws. Both cigarette taxes and smoke- free air laws are highly likely to originate from a common source — the intensity of anti-smoking sentiments upheld by a respective state. If SFA laws are correlated to the pattern of alcohol consumption, the coefficients on cigarette prices may be confounded due to the measure of SFA laws not being accounted for. However, if cigarette taxes and SFA laws share the same data-generating process, including both in the model could create colleniarity. Another reason for favoring cigarette prices instead of taxes is to reduce such an issue, as cigarette prices are comprised of other exogenous factors, such as transportation costs and retailing costs, which are likely to be unaffected by the imposition of SFA laws. Each SFA law (smoking bans in bars, restaurants, and private places) is added separately to the model to reduce multicollieniearity and results are estimated by the two-part model. The findings are shown in Table A1 and are robust to the inclusion of SFA laws.

8B. Smoking Restrictions. As a form of a robustness check, the alternative specification also accounts for the number of smoking restrictions imposed by the states. Restrictions imposed in bars, malls, workplaces, school areas, governmental buildings, restaurants, childcare center, and public transit are all considered. Counts of restrictions against smoking are correlated to cigarette prices. States with high anti-smoking sentiments are likely to have both higher cigarette prices and number of smoking restrictions. Failing to account for the number of restrictions might overestimate the effect of higher cigarette prices if the number of restrictions are correlated to drinking. However, the main findings are robust to the estimation performed after accounting for the counts of smoking restrictions, as shown in Table A1. For instance, the magnitude of the coefficient on the interaction term from the second part model in the last column is 0.0712 and is statistically significant at a 5 percent level. This indicates that the MSA changed the relationship between cigarettes and alcohol. Such a magnitude is similar to that from Table 2, Column 2.

8C. Smoked Versus Never Smoked. BRFSS categorizes one's smoking behavior as "never smoked" if a respondent reports not having smoked more than 100 cigarettes in a lifetime. To see the effect of increases in cigarette prices on alcohol consumption according to the smoking status, the sample is divided into those reporting having smoked and those who have never smoked. A priori, the effect of increases in higher cigarette prices should be pronounced on those who have smoked or at risk of smoking than compared to non-smokers, as both alcohol and cigarettes falls in their bundle. Hence, a falsification test is performed on non-smokers. It has to be noted that higher cigarette prices may also affect the alcohol consumption of non-smokers who would have otherwise smoked in the absence of the rise in cigarette prices. Such individuals may compensate their desire to smoke by increasing their alcohol intake. Considering the habit-building aspect of alcohol consumption may further magnify the effect of higher cigarette prices on non-smokers. Although this is not a perfect test, it provides suggestive evidence regarding the validity of the findings of this study.

Table A2 shows the results once the sample is divided by smoking status. The results indicate that for those reporting having never smoked, there is no statistical evidence at the conventional levels that higher cigarette prices after the MSA changed the relationship between cigarette use and alcohol consumption. However, the net effect for the post-MSA period is positive; suggesting that higher cigarette prices after the MSA might have led people to substitute cigarettes for alcohol among those reported having not smoked. It is possible that such an effect is driven by the extensive margin (i.e., potential smokers who did not smoke due to higher cigarette prices). Focusing among those reporting having smoked, the effect of higher cigarette prices on alcohol consumption is more pronounced. The coefficient on cigarette price suggests that before the MSA period, increases in cigarette prices are associated with a reduction in alcohol consumption. However, the coefficient on the interaction term for the second part model among those who reported smoking suggests that increases in cigarette prices after the MSA changed the relationship between cigarettes and alcohol, with smokers increasing their intake of alcohol, thus indicating substitution. Such an effect is significant at a 5 percent level. Compared to the group of individuals who never smoked, the magnitude on the variables of interest for those who smoked is larger. This provides further evidence that the results of higher cigarette prices on alcohol consumption are not spurious.

8D. Measurement Error. It is widely believed that individuals misreport (mostly under-report) their consumption of alcoholic beverages (Pernanen, 1974; Polich and Orvis, 1979; USDHHS, 1983; 1987). In contrast, Anda et al. (1987, 1988) finds that the self-reported measure of alcohol consumption is highly correlated to the objective measures of alcohol consumption, such as alcohol-related crashes and injuries. To help understand the potential issue of the measurement error of alcohol consumption in self-reported data, the trend of self-reported alcohol consumption is compared to gallons of beer sold. The per capita consumption of alcoholic beverages can be viewed as an objective measure of alcohol consumption, which is likely to be free from a substantial amount of measurement error. The state- level data of alcohol consumption for the years 1990 to 2007 is obtained from the National Institute on Alcohol Abuse and Alcoholism database. Figure 3 shows the trend of per capita beer consumption (obtained by the sales of beer) and mean drinks per month among the current drinkers in the sample.[51] From the figure, it is apparent that the sales of beer and self-reported alcohol consumption experienced a decreasing trend in the early half of the 1990s. After 1998, both the self-reported measure of alcohol consumption and per-capita beer consumption increased before experiencing a drop in 2004. The trend in self-reported alcohol consumption mirrors that of per-capita beer consumption. Though this evidence lessens the concern of measurement error, the potential issue of measurement error should not be taken for granted and hence requires further discussion.

If measurement error in the dependent variable (self-reported alcohol consumption) is of a classical type, then the coefficient on cigarette prices will be consistently estimated though such an error will lead to a loss in precision.[52] It is problematic if a measurement error in self-reported alcohol consumption is correlated with cigarette prices, although such a possibility is unlikely. In the event of misreporting, the coefficient on cigarette prices will be unbiased if misreporting happens with the same fraction throughout the distribution of alcohol consumption. Due to the role of alcoholism denial and the stigma attached to heavy drinking, heavy drinkers are less prone to correctly report alcohol consumption than moderate and light drinkers. As such, the coefficient

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[51] It has to be noted that the calculation of per capita beer consumption does not restrict the age group, whereas the focus of this study is 18-to-24-year olds.

[52] In other words, if the measurement error is not systematically correlated with the variable of interest (cigarette prices), then the coefficient on cigarette prices should be consistently estimated; although the presence of measurement error will adversely affect precision.

on the cigarette prices for heavy drinkers will be biased downwards (towards zero).[53] Measurement error can also be introduced when the state average of cigarette prices are used instead of the actual expenditure of cigarettes incurred by an individual. In this case,measurement issue in cigarette prices will increase the signal to noise ratio which will bias the cross-price estimates towards zero.[54]

8E.Reverse Causality. If increases in cigarette prices after the MSA occurred in those states where the pattern of drinking was increasing during the post-MSA period, then the findings of this study would be due to reverse causality. The results obtained would be prevalent even with the absence of increases in cigarette prices. To test for this, a simple regression is performed to check if alcohol consumption between 1991 and 1997 predicts the cigarette prices between 1999 and 2005. The results from such a regression provide no indication that past drinking predicts the future cigarette prices. This provides evidence against the possibility of reverse causality. Such finding are not shown in this paper but are available upon request.

8F.Border Effect. There exists a possibility that consumers living in counties close to the border of another state might travel across the border to purchase cigarettes if the cigarette prices are cheaper in the bordering state. An occurrence of cross-border shopping for cigarettes may understate the effect of higher cigarette prices on alcohol consumption as the cigarette price such consumers face are lower than the ones assigned to them in the study. To account for the border effect, minimum distance from the centroid of the bordering counties to the state border is controlled for. If a county borders two states, then the shortest distance from the center of county

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[53] If the reported number of drinks by heavy drinkers is less than the actual drinks following an increase in cigarette prices, the coefficients on cigarette prices for the heavy drinkers will be biased downwards.

[54] The actual cigarette price faced by an individual can be written as $cig\,price_{its} = cigprice_{ts} + u_{its}$. Here; the cigarette price faced by an individual ($cig\,price_{its}$) is the sum of the mean of average state cigarette prices at time t and some error term u_{its}.

to the state border is considered.[55] Including the border effect in the model does not change the results. The findings are not shown in this paper but are available upon request.

9. Conclusion

This paper examines the consequences of increases in cigarette prices after the tobacco settlement on young adults' alcohol consumption by using sizeable increases in cigarette prices as a source of natural experiment. The study examines whether higher cigarette prices after the MSA altered consumers' (young adults') initial preference between cigarettes and alcohol. Considering the cases of negative externalities associated with heavy drinkers, the paper also focuses on the differential effects of higher cigarette prices on alcohol consumption.

The empirical results of this paper point out four main findings. First, increases in cigarette prices in the post-MSA period influenced light, moderate, and heavy drinkers to substitute alcohol for cigarettes. Such an effect is more pronounced among smokers. Second, higher cigarette prices after the MSA changed young adults' initial taste or preference between cigarettes and alcohol. In other words, higher cigarette prices after the MSA built substitutability from cigarettes to alcohol among young adults' even though such an effect is not found in the pre-MSA period. Third, for the older cohort (21-to-24-year olds), increases in cigarette prices in the post-MSA period mostly affected binge drinkers. Fourth, findings suggest that higher cigarette prices are associated with an increase in drunk driving fatalities. This piece of evidence further supports the substitution of alcohol for cigarettes, as the only possible channel through which higher cigarette prices can increase alcohol-related fatal accidents is by increases in drinking.

The findings of this paper are policy relevant; specifically, when state and federal governments show initiative in increasing cigarette taxes but are disinclined to raise alcohol taxes. For instance, federal taxes on alcohol has not increased since 1991 (5 cents per 12 oz. bottle of

[55] For those counties not bordering the state line, I assign a value of 0. A dummy variable is created to indicate whether a county borders a state line and is included in the specification.

beer); whereas, federal cigarette taxes was raised to $1.01 in 2009. President Obama's proposed budget for 2015 further includes a 94 cent increase per pack of cigarettes. Due to such a disproportionate allocation of taxes, the real price of alcohol has plummeted over the past decades and that of cigarettes has risen. In addition, the door for tobacco litigation could still be sought at the federal level, which could lead to further increases in cigarette prices. By evaluating a historical event, the results of this study strongly indicates the need for considering the interdependent nature of cigarettes and alcohol when considering higher cigarette taxes or agreements, which could potentially lead to increases in cigarette price.

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Figure 1

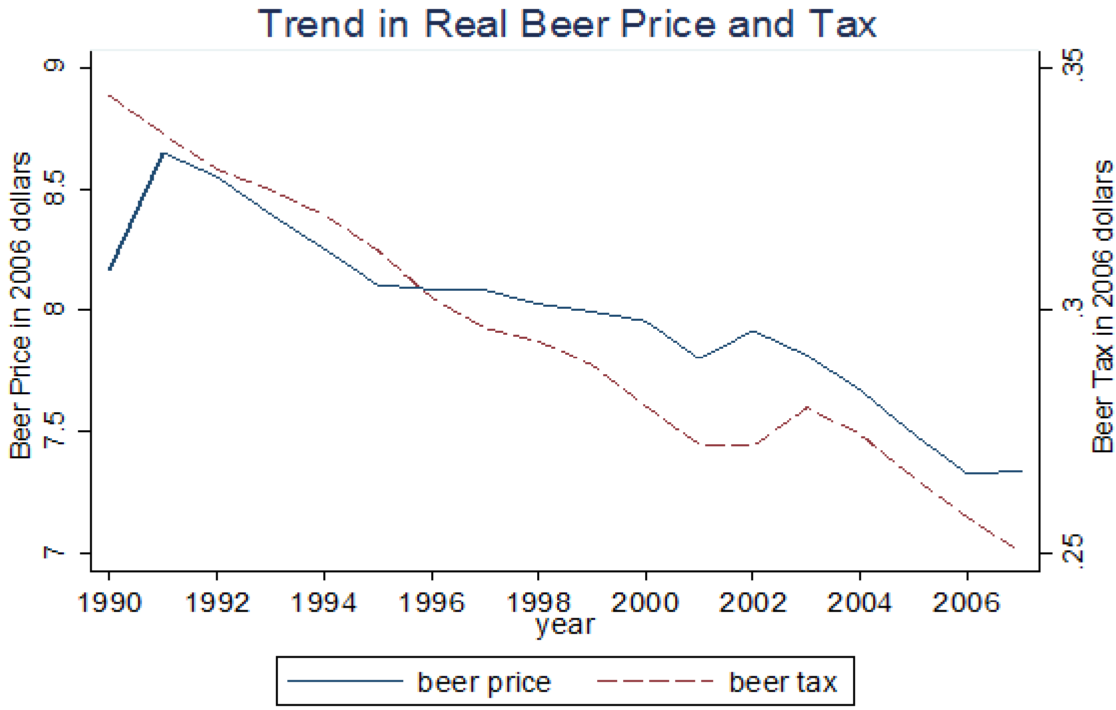


Figure 2

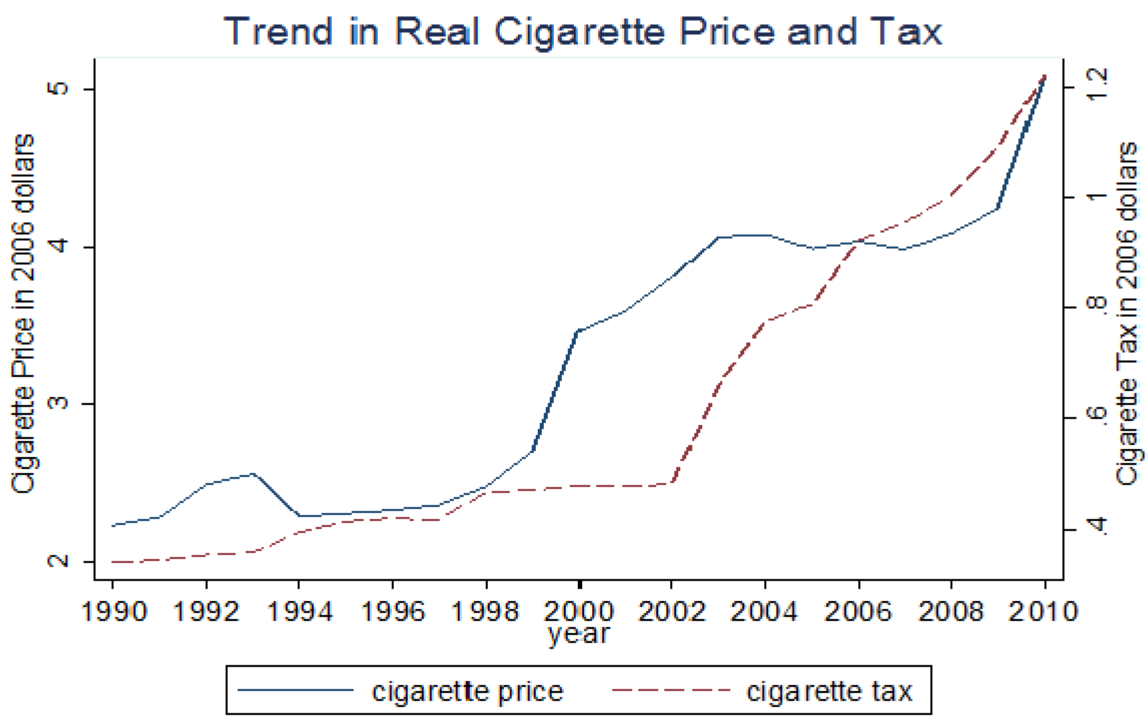


Figure 3

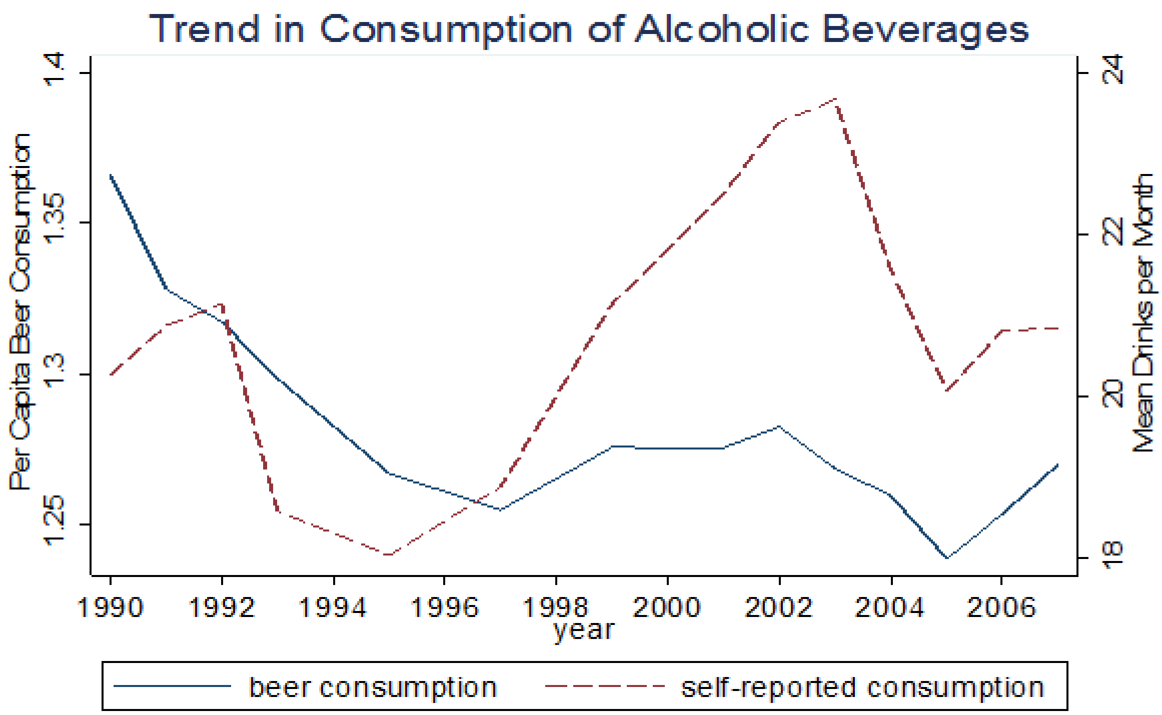


Figure 4

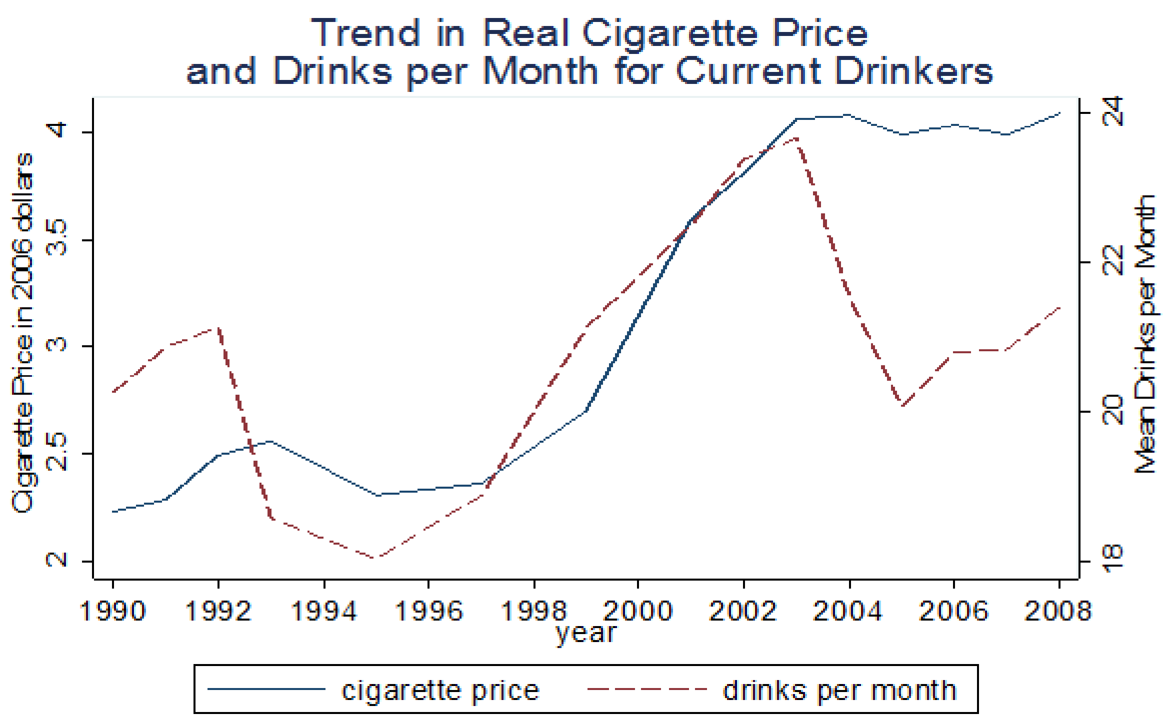


Figure 5

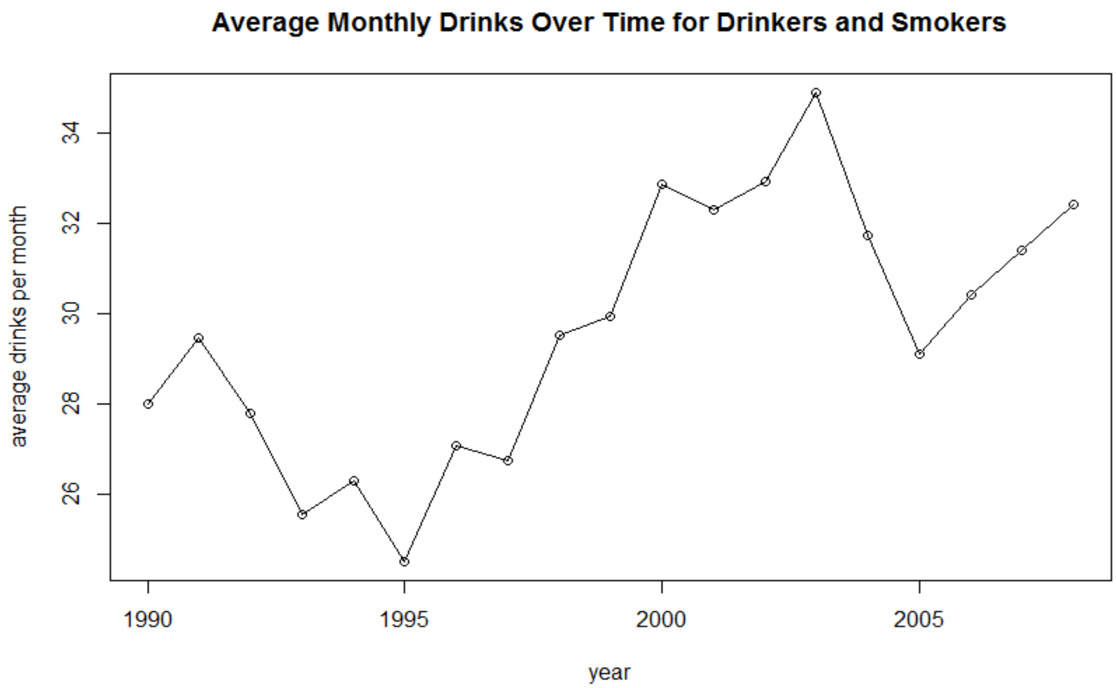


Figure 6

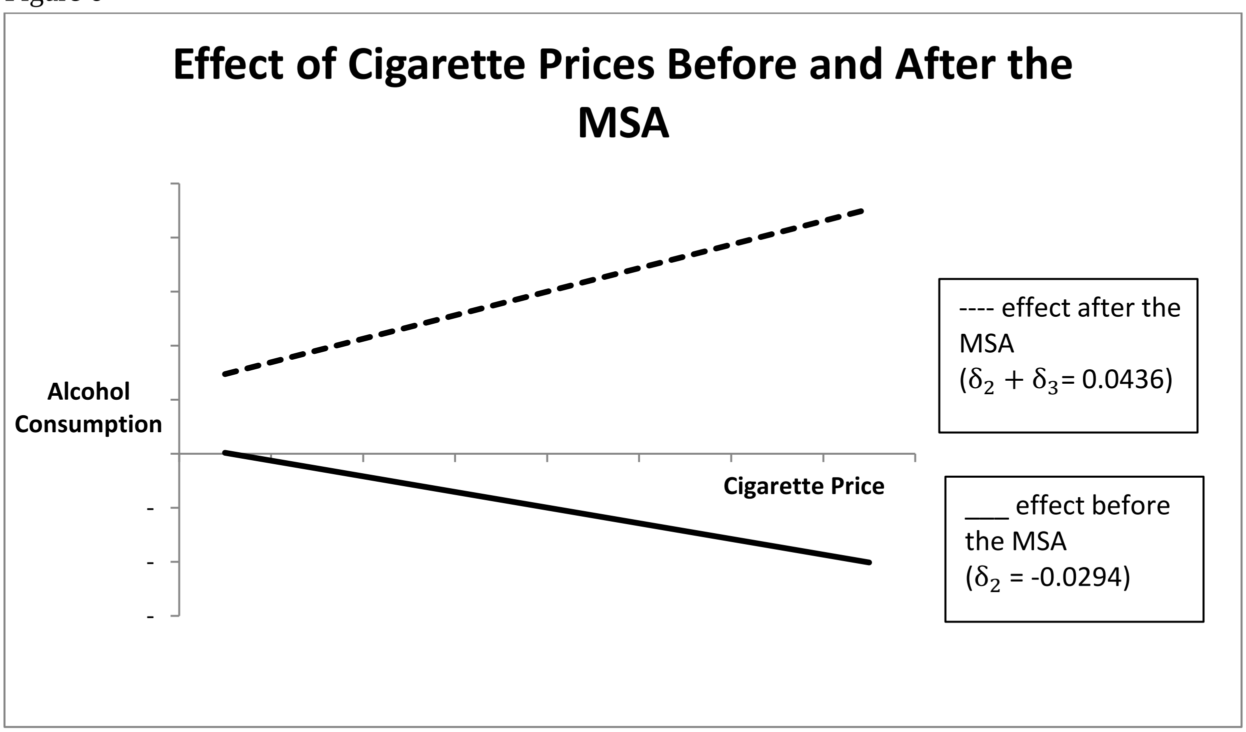
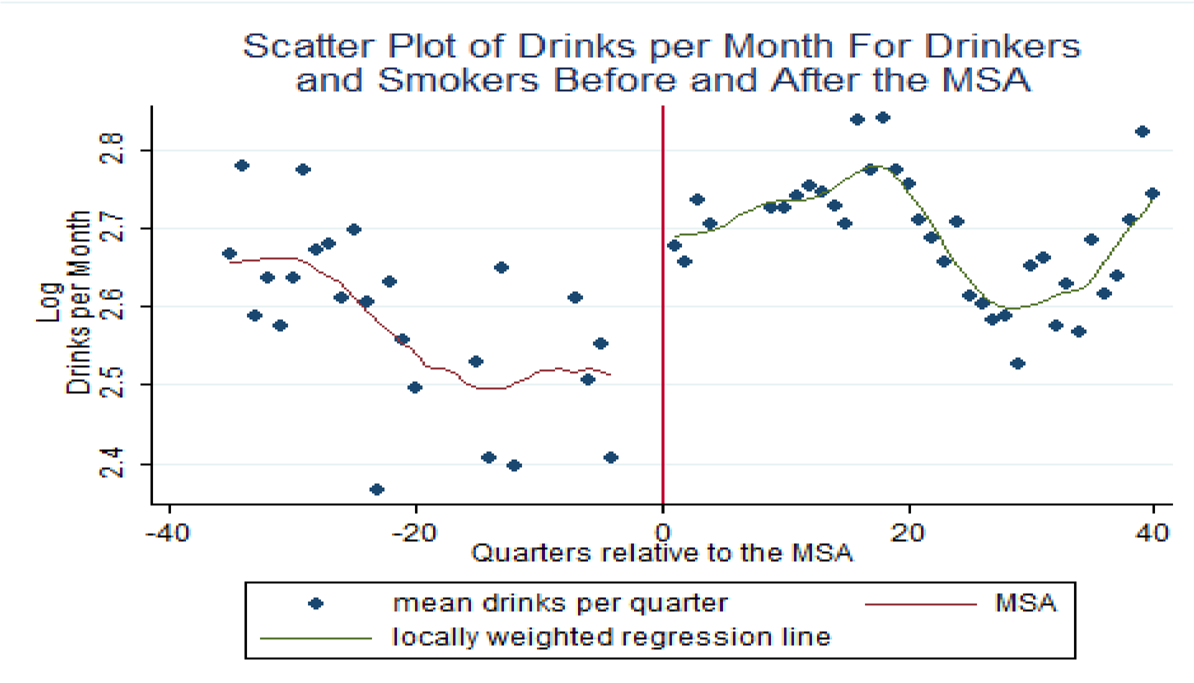
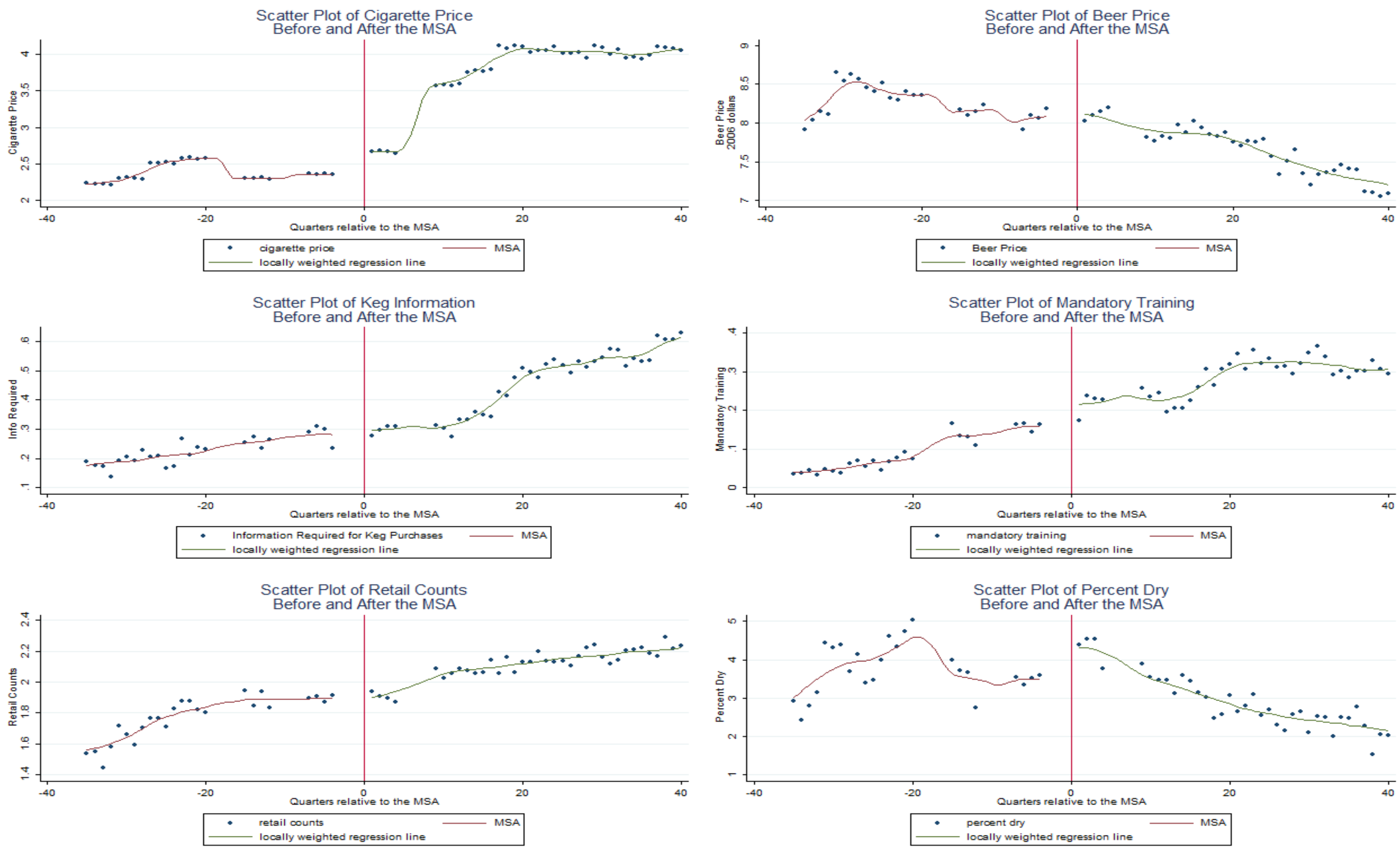


Figure 7a



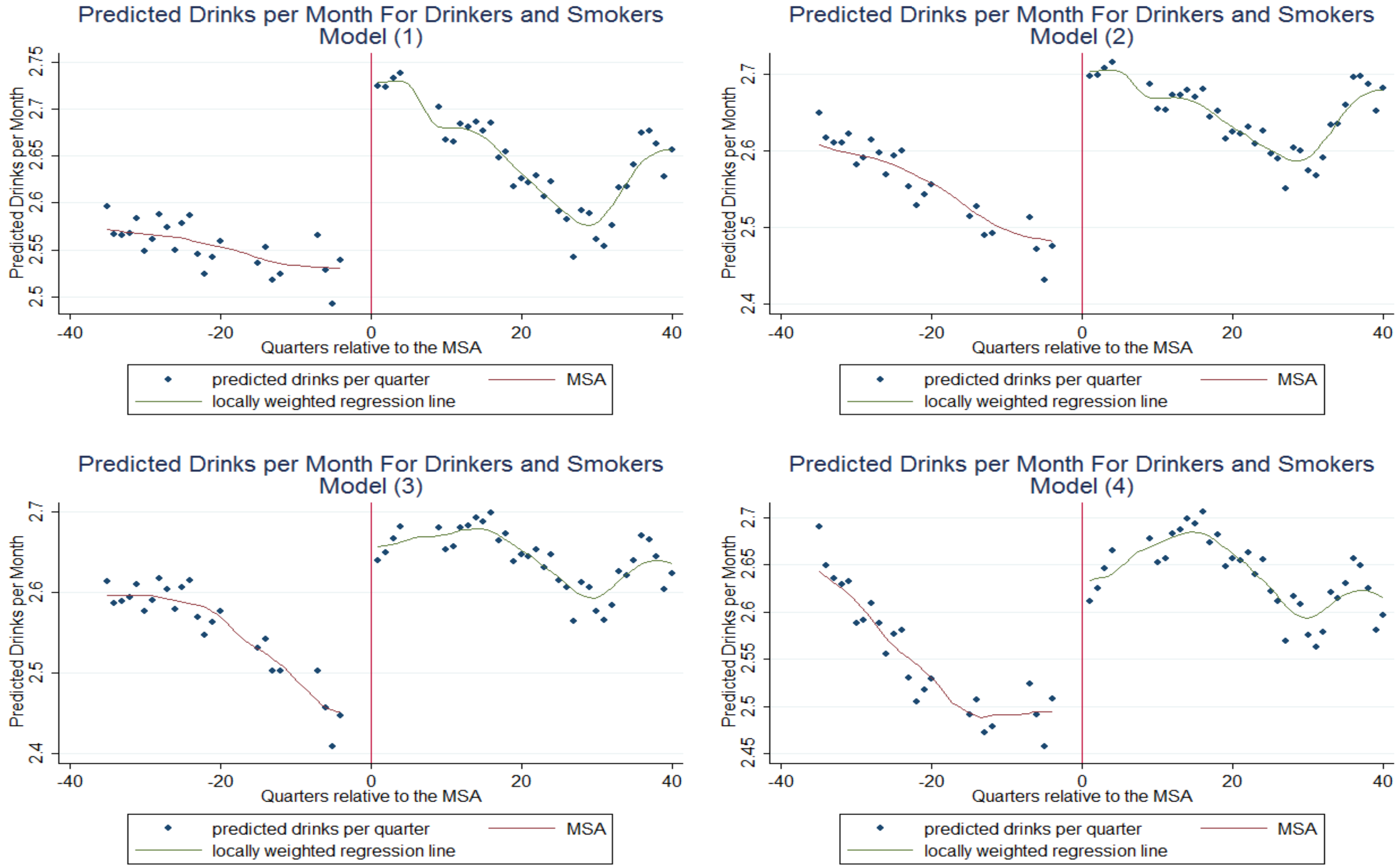
Note: The figure shows the trend in log of drinks per month for drinkers and those reported having smoked cigarettes. The running variable above represents quarters away from the period of MSA. For example running 20 can be read as 20 quarters after the MSA period. The smooth lines represent a locally weighted regression line. Figure 12a highlights discontinuity around the MSA period.

Figure 7b



Note: The figure above tests whether there is any discontinuity around the MSA period among other baseline covariates that could influence alcohol consumption. As expected, there is a slight discontinuity in cigarette prices; however, the jump is more pronounced ten quarters after the MSA. This suggests that cigarette prices increased gradually. The graphs depict no discontinuity among beer prices, information required for keg purchases, mandatory training, and retail counts.

Figure 7c



Note: The graphs above represent the predicted values of log of drinks consumed per month for both current drinkers and individuals having reported smoked cigarettes obtained from the respective models depicted in Panel B of Table 4. Predicted values obtained from Model (4) closely resemble the actual values of log of drinks per month shown in Figure 12a. The graphical approach prefers the functional form implemented in Model (4).

Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.
Dependent Variable		
current drinker	0.57	0.495
drinks per month	12.023	22.498
log of drinks per month	2.334	1.271
Independent Variable		
real beer price	7.843	1.047
real cigarette price	3.383	0.937
keg info required	0.389	0.487
fake ID support	2.035	0.873
mandatory training	0.229	0.42
training incentives	0.271	0.445
Sunday ban	0.302	0.459
Personal Characteristics		
age	21.407	1.994
education less than high school	0.102	0.303
high school, or GED	0.328	0.47
some college/college graduates	0.551	0.497
sex (1=male)	0.429	0.495
income<10,000	0.127	0.333
income 10,000 to 14,999	0.095	0.293
income 15,000 to 19,999	0.126	0.331
income 20,000 to 24,999	0.142	0.349
income 25,000 to 34,999	0.167	0.373
income 35,000 to 49,999	0.14	0.347
income >= 50,000	0.102	0.302
White	0.712	0.453
Black	0.108	0.31
Hispanic	0.051	0.22
Asian/Hawaiian/Pacific Islander	0.083	0.277
other race	0.045	0.208
employed for wages	0.584	0.493
self-employed	0.039	0.192
unemployed (>1 year)	0.021	0.143
unemployed (<1 year)	0.056	0.23
homemaker	0.06	0.237
student	0.227	0.419
unable to work	0.013	0.115
married	0.224	0.417
divorced/widowed/separated	0.035	0.183

never married	0.662	0.473
member of unmarried couple	0.08	0.271

*Note: N= 165,804 for all variables with exception of log of drinks per month, where N=94,432. The displayed means are unweighted.

Table 2. Effect of Cigarette Prices on Alcohol Consumption (includes both smokers and non-smokers)

	prevalence	OLS	20th quantile	30th quantile	40th quantile	60th quantile	70th quantile	80th quantile	90th quantile
real cigarette price	0.0038	-0.0294	-0.0537	-0.0282	-0.0777	-0.0253	-0.0135	0.0139	-0.0212
	(0.0214)	(0.0398)	(0.0593)	(0.0526)	(0.0491)	(0.0529)	(0.059)	(0.0576)	(0.0573)
post MSA*real	-0.0018	0.073**	0.0997**	0.0807*	0.1147**	0.0638	0.0512	0.0272	0.0536
cigarette price	(0.0205)	(0.0348)	(0.0535)	(0.0478)	(0.0471)	(0.0487)	(0.053)	(0.0515)	(0.0482)
real beer price	-0.0049	0.0076	0.0107	0.0105	0.0135	0.0045	0.0104	0.0091	0.006
	(0.0051)	(0.0077)	(0.0121)	(0.0110)	(0.0115)	(0.0109)	(0.013)	(0.0101)	(0.0085)
effect after the MSA	*0.002*	*0.0436****	*0.046***	*0.0525****	*0.037**	*0.0385***	*0.0377***	*0.0411***	*0.0324**
	(0.0057)	*(0.0122)*	*(0.0214)*	*(0.0177)*	*(0.0189)*	*(0.0161)*	*(0.018)*	*(0.0184)*	*(0.0192)*
predicted log of drinks		2.33	1.27	1.69	2.06	2.71	3.03	3.41	3.88
predicted drinks per month		10.278	3.561	5.419	7.846	15.029	20.697	30.265	48.424
N	165,804	94,432	94,432	94,432	94,432	94,432	94,432	94,432	94,432

Note: The dependent variable for the first part model is drinking status (1=current drinker) and for the second part is log of number of drinks consumed per month given that he/she is a current drinker. Additionally, models control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, state's alcohol importance, alcohol-related driving fatalities, year fixed effects, whether keg information is required, number of fake ID counts, mandatory training, training incentives, exceptions, Sunday bans, and state fixed effects. For the OLS and linear probability models, robust standard errors clustered by states are reported in parenthesis. Bootstrapped standard errors clustered by states and obtained from 199 replications are presented for the results pertaining to quantile regression.* indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 3. Effect of Cigarette Prices on Alcohol Consumption for Smokers

	prevalence	OLS	20th quantile	40th quantile	60th quantile	70th quantile
real cigarette price	0.0026	-0.0817	-0.1029	-0.0874	-0.0489	-0.0499
	(0.021)	(0.068)	(0.096)	(0.078)	(0.072)	(0.080)
post MSA* real cigarette price	-0.0017	0.1518**	0.2070***	0.1728***	0.1248**	0.1233*
	(0.017)	(0.058)	(0.078)	(0.061)	(0.063)	(0.074)
Real beer price	-0.0008	0.0104	0.0238	0.0069	0.0047	0.0104
	(0.004)	(0.010)	(0.017)	(0.015)	(0.014)	(0.013)
effect after the MSA	*0.0009*	*0.0701****	*0.1041****	*0.0854***	*0.0759****	*0.0734****
	(0.008)	*(0.018)*	*(0.036)*	*(0.033)*	*(0.025)*	*(0.024)*
predicted log of drinks		2.625	1.613	2.386	3.016	3.339
predicted drinks per month		13.8	5.02	10.87	20.41	28.19
N	59,943	41,534	41,534	41,534	41,534	41,534

Note: The dependent variable for the first part model is drinking status (1=current drinker) and for the second part is log of number of drinks consumed per month given that he/she is a current drinker. Additionally, models control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, state's alcohol importance, alcohol-related driving fatalities, year fixed effects, whether keg information is required, number of fake ID counts, mandatory training, training incentives, exceptions, Sunday bans, and state fixed effects. For the OLS and linear probability models, robust standard errors clustered by states are reported in parenthesis. Bootstrapped standard errors clustered by states and obtained from 199 replications are presented for the results pertaining to quantile regression.* indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 4. Effects of MSA on Alcohol Consumption (Global RD Design)

Dependent Variable: Log of Monthly Alcohol Consumption	model (1)	model (2)	model (3)	model (4)
Panel A. without covariates				
treatment (post MSA period)	0.1962***	0.2296***	0.2264***	0.1377**
	(0.0303)	(0.0339)	(0.0342)	(0.0539)
N	41534	41534	41534	41534
r2	0.0091	0.0093	0.0093	0.0094
Panel B. with covariates				
treatment (post MSA period)	0.2058***	0.2548***	0.2470***	0.0870*
	(0.0316)	(0.0359)	(0.0364)	(0.0502)
N	41,534	41,534	41,534	41,534
r2	0.1364	0.1367	0.1370	0.1374

Note: The dependent variable is the log of the number of drinks consumed per month given that an individual reported having smoked. Both Panels include state fixed effects. Additionally, Panel B control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, alcohol importance, alcohol-related driving fatalities, whether keg information is required, number of fake IDs count, mandatory training, training incentives, exceptions, and Sunday bans. Robust standard errors clustered by states are reported in parenthesis. * indicates $p<0.10$; ** indicates $p<0.05$; and *** indicates $p<0.01$.

Table 5. MSA and Alcohol Consumption

Dependent variable: Log of Monthly Alcohol Consumption	Local Linear (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)
treat (Post MSA period)	0.255***	0.31**	0.29**	0.14***	0.125***
	(0.110)	(0.140)	(0.126)	(0.040)	(0.037)
quarters away from MSA		-0.0456	-0.04	-0.0009	-0.0012
		(0.024)	(0.022)	(0.002)	(0.002)
quarters away from MSA*Post MSA period		0.05**	0.059**	0.0031	0.0067
		(0.025)	(0.022)	(0.003)	(0.002)
Full Controls	No	No	Yes	No	Yes
Sample	12.4 quarters	10 quarters	10 quarters	25 quarters	25 quarters
Observations	9838	6300	6300	26013	26013

Note: The dependent variable is the log of the number of drinks consumed per month given that an individual reported having smoked. Column (1) uses the bandwidth of 12.4 quarters away from the MSA, column (2) and (3) uses the window of 10 quarters away from the MSA, and columns (4) and (5) uses 25 quarters away from the MSA. Additionally, columns (3) and (5) control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, alcohol importance, alcohol-related driving fatalities, whether keg information is required, number of fake IDs count, mandatory training, training incentives, exceptions, and Sunday bans. No columns include state fixed effects. Robust standard errors are reported in parenthesis. * indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 6. Results from the Finite Mixture Model (years 1999 to 2008)

Dependent Variable:	18-to-24-year olds		18-to-20-year olds		21-to-24-year olds	
Drinks per Month	component 1	component 2	component 1	component 2	component 1	component 2
real cigarette price	0.0033	0.0659**	-0.0871	0.0119	-0.0841	0.0781**
	(0.110)	(0.027)	(0.193)	(0.053)	(0.096)	(0.033)
real beer price	-0.03	0.0221*	-0.0068	0.0614**	-0.0404	0.0068
	(0.053)	(0.012)	(0.191)	(0.031)	(0.058)	(0.013)
N	113,003	113,003	36,397	36,397	76,606	76,606
predicted drinks	3.328	22.760	1.954	23.735	4.811	22.496
sum of posterior probability	0.528	0.472	0.649	0.351	0.516	0.484

Note: The dependent variable is number of drinks consumed per month (including for the non-drinkers). Additionally, models control for whether keg information is required, the number of fake id counts, mandatory training, training incentives, exceptions, Sunday bans, year fixed effects, state fixed effects, and personal characteristics. Robust standard errors clustered by states are reported in parenthesis. *indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 7. Determinants of Prior Probabilities

	18-24-year olds	18-20-year olds	21-24-year olds
	prior probability of component 1	prior probability of component 1	prior probability of component 1
age	-0.3154***	-0.4183***	-0.0424*
	(0.023)	(0.035)	(0.024)
divorced/widowed/ separated	-0.4975***	-1.0809***	-0.4761***
	(0.128)	(0.264)	(0.147)
never married	-0.9120***	-0.7076***	-0.9020***
	(0.063)	(0.157)	(0.096)
member of unmarried couple	-1.1459***	-0.8825***	-1.1310***
	(0.097)	(0.152)	(0.130)
high school or GED	0.2361***	-0.0232	0.2902***
	(0.061)	(0.157)	(0.092)
some college/college graduate or more	0.8231***	0.4841*	0.7894
	(0.211)	(0.284)	(0.643)
unemployed	0.4440***	0.2358**	0.5247***
	(0.068)	(0.112)	(0.071)
homemaker	1.1171***	1.0402**	0.8546***
	(0.125)	(0.493)	(0.152)
student	0.1159**	0.0728	0.0285
	(0.050)	(0.067)	(0.088)
unable to work	1.2869***	0.4633**	1.2473***
	(0.217)	(0.231)	(0.182)
Blacks	1.0418***	0.7887***	1.0376***
	(0.125)	(0.203)	(0.222)
Hispanic	0.6220***	0.2935*	0.8619***
	(0.207)	(0.152)	(0.287)
Asian/Hawaian/Pacific Islander	0.5470***	0.4784***	0.6028***
	(0.160)	(0.131)	(0.227)
other race	0.3567***	0.1128	0.4449***
	(0.119)	(0.160)	(0.127)
N	113,003	36,397	76,606

Note: The estimates of the prior probability are estimated along with the estimates presented in Table 5. They are shown in a separate table because of space issues. Robust standard errors clustered at the state level are presented in parenthesis. *indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 8. Determinants of Posterior Probability of Component 2

	18 to 24	21 to 24
	Component 2	Component 2
Binge drinkers	0.3829***	0.3417***
	(0.012)	(0.012)
current smoker	0.1148***	0.1064***
	(0.007)	(0.008)
age	0.0635***	0.0111***
	(0.001)	(0.001)
never married	0.1584***	0.1701***
	(0.004)	(0.005)
member of unmarried couple	0.2043***	0.2187***
	(0.007)	(0.007)
high school or GED	-0.0616***	-0.0636***
	(0.005)	(0.006)
some college/college	-0.0423***	-0.0431***
	(0.004)	(0.004)
income < 10,000	-0.0170***	-0.0195***
	(0.005)	(0.006)
income 15,000 to 19,999	-0.0146***	-0.0137***
	(0.005)	(0.005)
income 20,000 to 24,999	-0.0081	-0.0121**
	(0.005)	(0.005)
income 25,000 to 34,999	-0.0009	-0.002
	(0.005)	(0.005)
income 35,000 to 49,000	0.0068	0.0069
	(0.005)	(0.006)
black	-0.1577***	-0.1767***
	(0.008)	(0.009)
hispanic	-0.1016***	-0.1573***
	(0.010)	(0.011)
N	113,003	76,606
r2	0.3746	0.3386

Note: Posterior probabilities obtained after estimating a two-component variant finite mixture model for the responsive group are regressed on variables included in the above table. Additional variables include unemployment measures and year dummies. Robust standard errors clustered at the state level are presented in parenthesis. *indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table 9. Effect of Higher Cigarette Prices on Traffic Fatalities

Panel A (BAC>0)	(1)	(2)	(3)
Dependent Variable:	**accident rate**	**log(number of accidents)**	**count of accidents**
real cigarette price	0.0013**	0.16*	0.1018**
	(0.0000)	(0.0899)	(0.0474)
real beer tax (in cents)	-8.74E-05***	-0.0157***	-0.0100
	(0.0000)	(0.0034)	(0.0062)
smoking ban in bars	0.0022***	0.342***	0.4170***
	(0.0000)	(0.147)	(0.0632)
N	306	306	306
Panel B (BAC=0)	(1)	(2)	(3)
Dependent Variable:	**accident rate**	**log(count of accidents)**	**count of accidents**
real cigarette price	9.23E-04	-0.0196	-0.0650**
	(0.0000)	(0.066)	(0.0323)
real beer tax (in cents)	1.18E-04	0.0049***	0.0053***
	(0.0000)	(0.001)	(0.0019)
smoking ban in bars	0.0001***	0.471***	0.4289***
	(0.0000)	(0.0468)	(0.0283)
N	306	306	306

Note: The dependent variables used in column (1), (2), and (3) are the accident rate (count of accidents/population of 18-to-24-year olds), the log of count of accidents, and count of accidents, respectively for 18-to-24-year olds. The first two columns are estimated by using fixed effect models and the third column represents the results from a poisson model. The models control for the log of per capita income, unemployment rate, minimum wage, log of accident rate not related to alcohol consumption for 18-to-24-year olds (only in Panel A), log of population of 18-to-24-year olds [in columns (2) and (3)], and state and year fixed effects. Robust standard errors clustered at the state level are presented in parenthesis. *indicates p<0.10, ** indicates p<0.05, and *** indicated p<0.01.

Table 10. Including Smoking Sentiments

	(1)		(2)		(3)		(4)	
	prevalence	OLS on drinkers	prevalence	OLS on drinkers	prevalence	OLS on drinkers	prevalence	OLS on drinkers
real cigarette price	0.0040	-0.0295	0.0044	-0.0313	0.0044	-0.0312	0.0042	-0.0308
	(0.0214)	(0.0398)	(0.0211)	(0.0398)	(0.0211)	(0.0399)	(0.0212)	(0.0397)
real beer price	-0.0047	0.0076	-0.0044	0.0067	-0.0043	0.0065	-0.0046	0.0070
	(0.0051)	(0.0077)	(0.0050)	(0.0077)	(0.0050)	(0.0077)	(0.0050)	(0.0078)
Post-MSA*real cigarette price	-0.0018	0.0730**	-0.0019	0.0741**	-0.0017	0.0733**	-0.0020	0.0743**
	(0.0205)	(0.0348)	(0.0203)	(0.0348)	(0.0203)	(0.0349)	(0.0203)	(0.0346)
smoking sentiments			-0.0140	0.0528				
			(0.0227)	(0.0373)				
lag of smoking sentiments					-0.0165	0.0536*		
					(0.0192)	(0.0297)		
lead of smoking sentiments							-0.0089	0.0431
							(0.0277)	(0.0459)
N	165,804	94,432	165,804	94,432	165,804	94,432	165,804	94,432
r2	0.1293	0.1271	0.1293	0.1271	0.1294	0.1272	0.1293	0.1271

Note: The dependent variable for the first part model is drinking status (1=current drinker) and for the second part is the log of the number of drinks consumed per month given that he/she is a current drinker. Additionally, models control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, alcohol importance, alcohol related-driving fatalities, whether keg information is required, number of fake ID counts, mandatory training, training incentives, exceptions, Sunday bans, and year and state fixed effects. Robust standard errors clustered by states are reported in parenthesis. * indicates p<0.10, ** indicates p<0.05, and *** indicates p<0.01.

Appendix

Figure A1

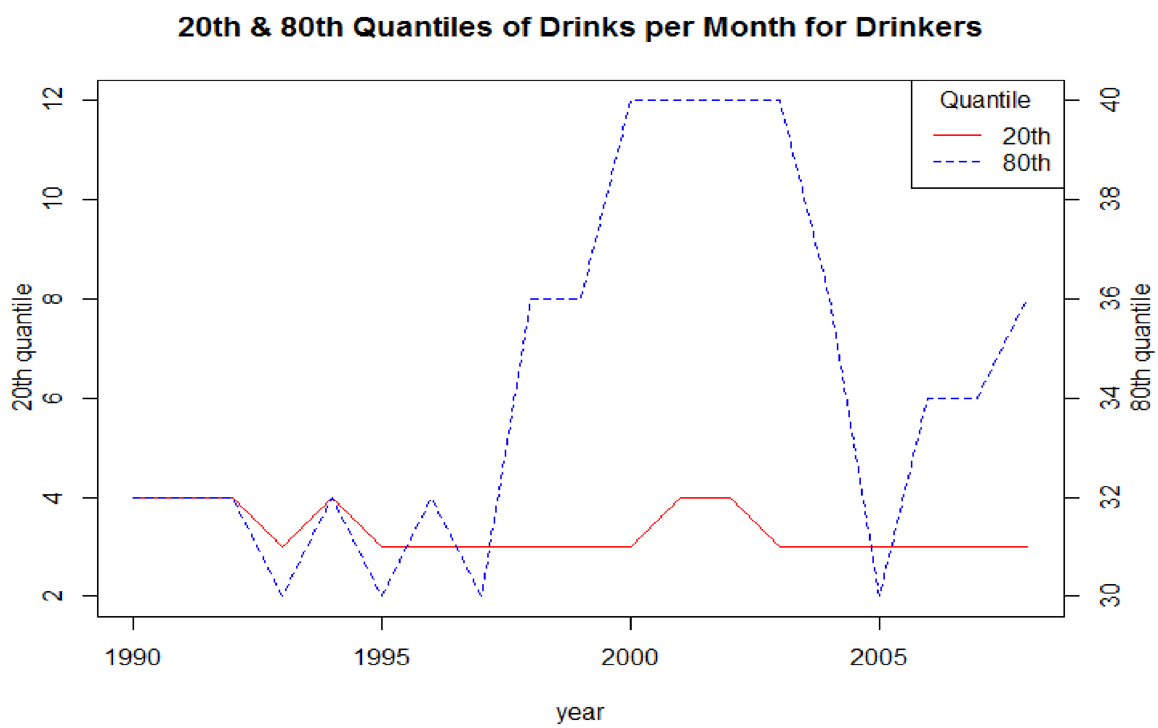


Figure A2

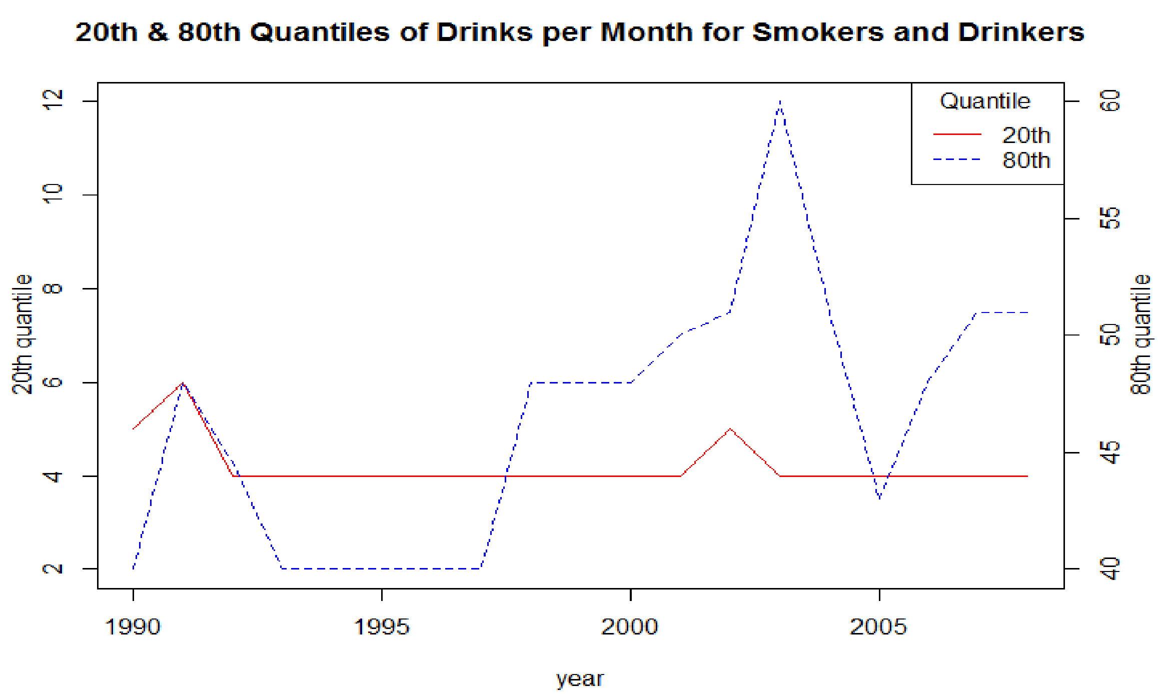


Figure A3

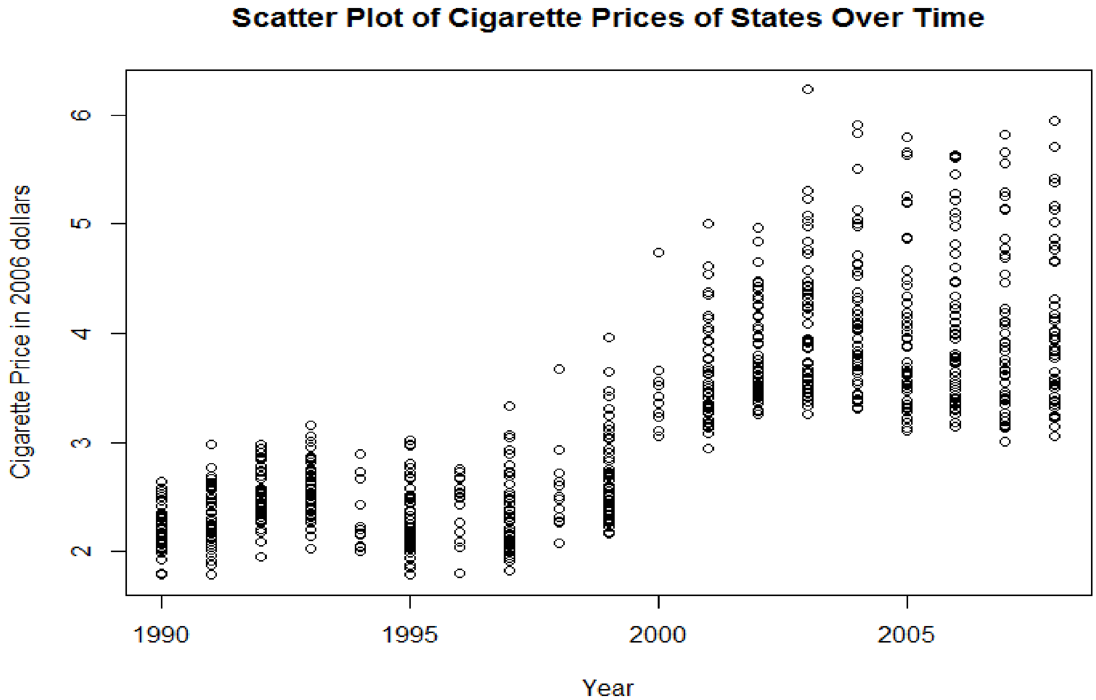


Figure A4

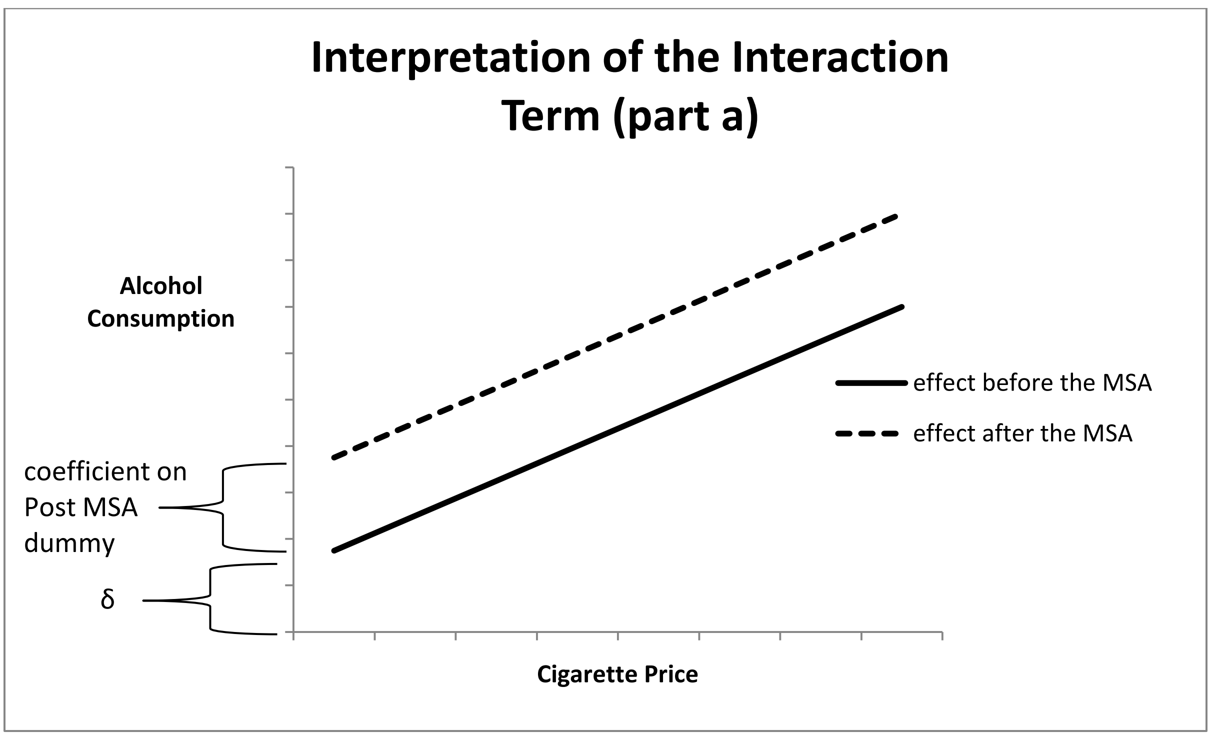


Figure A5

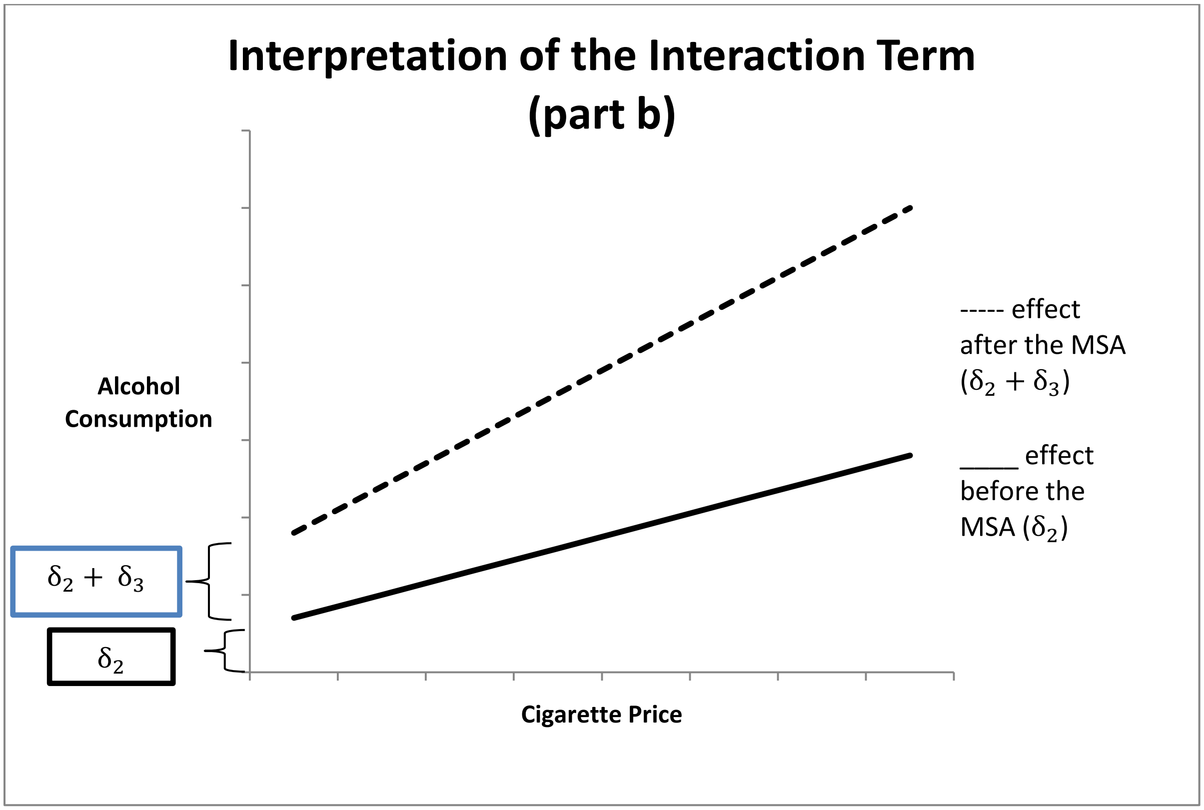
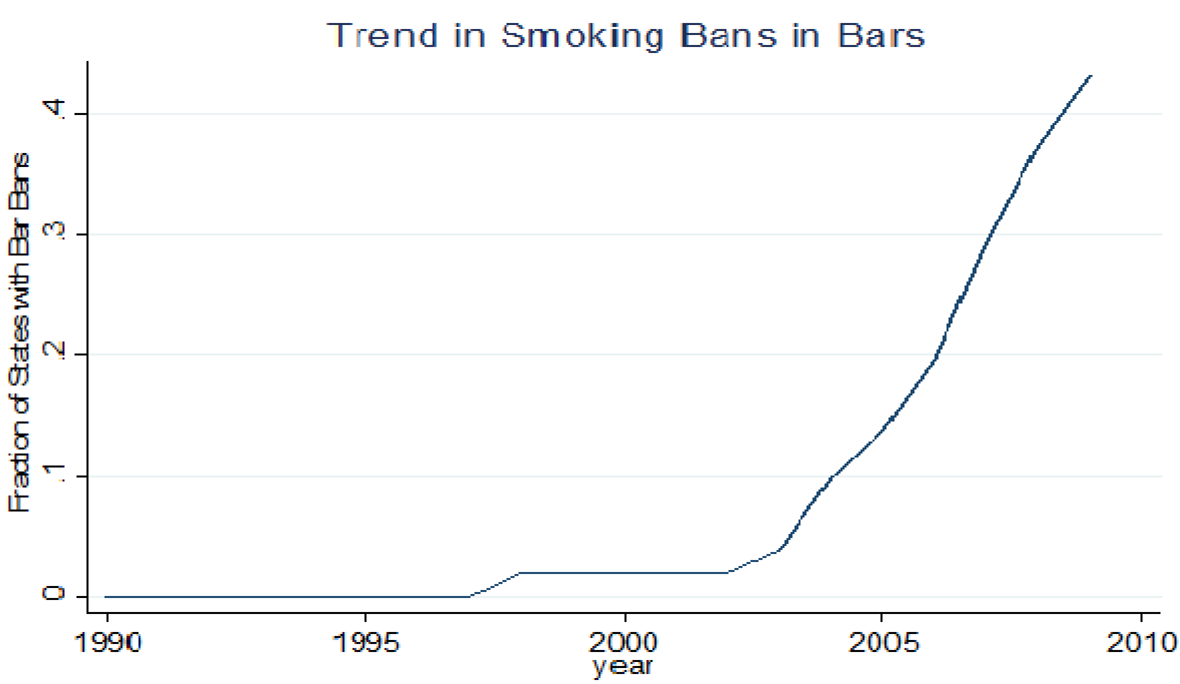


Figure A6



1. Data Sources

A. Alcohol Control Policies

1. Keg Information Required

While selling kegs, sellers can potentially impose restrictions by recording identifying information about the purchaser. A dichotomous variable is constructed assigning a value of "1" if the sellers in the respective states are required by law to record a buyer's information while purchasing kegs; otherwise, the value given is "0." Identifying information includes purchaser's name, address, telephone number, and driver's license number.

2. Drinking and Driving

To control for policies regarding underage drinking and driving, a state's blood alcohol concentration (BAC) limits for individuals below 21 years of age is considered. By 2006, all of the respondents lived in states with a zero tolerance level, but there exists a lot of variation in this matter as states have switched from a BAC limit of 0.10 or 0.08 percent to zero percent.

3. Fake ID Support and Training Laws

All sellers are required to ask for identification in order to verify that the purchaser is not underage. In some states, sellers have a bigger influence in discouraging the underage population from buying alcoholic beverages. In such states, sellers are provided with easier ways to identify the validity of the documentation provided by purchasers. This includes distinctive licenses for underage youths, initiatives for using electronic licenses, and the power to seize fake licenses. Moreover, some states have mandatory training laws for sellers and servers and also some states require employers to provide incentives for voluntary training.

4. Sales Restrictions

Laws regarding the sales of alcoholic beverages for off-premise consumption have been a recent topic of interest, as policy makers have been interested in boosting state revenue by additional sales of alcoholic beverages, yet at the same time remain concerned about the issue of underage drinking. Several states repealed the Sunday ban law in the past decade and a couple of them authorized a local option.[56] A dichotomous variable is created assigning a value of "1" if the Sunday ban prevails in the state; otherwise, the value given is "0." All of the variables pertaining to alcohol consumption are then merged to the BRFSS dataset by using the year of the interview and state of residence.

[56] Delaware, Maine, and Pennsylvania repealed Sunday ban sales law in 2003; whereas Rhode Island and Virginia repealed it in 2004. Arkansas and Kansas authorized a local option in years 1999 and 2005, respectively. A local option is adapted by local government of a state and is less restrictive than the state ban. States with authorized local options are coded as "1."

B. Other State Variables

1. Legalization of medicinal marijuana: To account for the relation between marijuana use and alcohol consumption established in the literature, legalization of medical marijuana is used (Cameron and Williams 1999; DiNardo and Lemieux 2001; Williams et al. 2001; Zhao et al. 2003).
2. Age-specific population and state population data is obtained from the U.S. Census Bureau.
3. The beer taxes are extracted from the Federation of Tax Administration website and are corroborated with the taxes in the Alcohol Policy Information System's (APIS) database.
4. State-level per capita income is obtained from the Bureau of Economic Analysis.
5. The number of outlets licensed to sell alcohol and the percentage of a state's population living in dry counties are taken from the *Adams Liquor Handbook*. These variables are accounted for in the models to capture both the market structure effects and ongoing sentiments regarding drinking.
6. Employees in the Alcohol Industry (Economic Importance of Alcohol): State legislatures are likely to support industries with a large number of employees (Benjamin and Dougan, 1997; and Feng, 1998), which is no different in the case of the alcohol industry. States that produce alcoholic beverages in a massive quantity, such as California (beer and wine), Missouri (Budweiser), Colorado (Coors), and Wisconsin (Miller), have relatively lower beer taxes. Similarly, the intensity of a lobbying effect often reflects upon the state's legislative actions. For instance, states with a strong lobbying presence for beer constituencies could lead to lower beer taxes.

   The percentage of people working in the alcohol industry in a state is used as a proxy for both the respective state's economic importance of alcohol and its lobbying presence. First, the states' specific total number of people working in an alcohol industry (beer, wine, and distilled beverages) is collected by referring to the designated Standard Industrial Classification (SIC) code (for 1997) and the North American Classification System (NAICS) descriptions (for the years 1998–2008) from the United States Census Bureau, County Business Pattern. Then the states' percentage of employed people working in the alcohol industry is calculated by using the total number of people employed in the labor market as the denominator. The resulting variable reflects the importance of the alcohol industry in a particular state. Employment numbers are extracted from the Bureau of Labor Statistics for the years used in this study.

7. Per capita alcohol consumption is obtained from the National Institute on Alcohol Abuse and Alcoholism database.

C. National Highway Traffic Safety Administration (NHTSA)

The data for fatal accidents is obtained from the Fatality Analysis Reporting System (FARS) of the National Highway Traffic Safety Administration (NHTSA). These are individual-level data and are aggregated to the state-level for the analysis. The primary variable of interest is the "annual number of fatal accidents in a state for which 18-to-24-year old had a blood alcohol concentration greater than "0." This could occur by three different means. First, a person in this age range could get into an accident all by himself, for example, say a person crashes into a tree while intoxicated. Second, a person in this age range could be intoxicated and then collide with someone in the same age range (18-to-24 year old). Third, a person in this specific age range (18-to-24 year old) could be intoxicated and crash with someone outside of this age range. To construct the fraction of the population at risk of fatal alcohol-related accidents, age specific information on the population is obtained from the U.S. Census Bureau. The alcohol-related fatal accident risk is then calculated by dividing the specific number of accidents by the age-specific population of the state (18-to-24-year olds). Similarly, the risk of fatal accidents not related to alcohol is calculated. In many cases, blood alcohol concentration (BAC) levels are not reported. The BAC level of the driver is imputed by "general location model" based on other characteristics of the accident, such as age, gender, safety belt or helmet use, license expiration, prior traffic convictions, day of the week, time of day, the role of the vehicle in the accident, whether the car remains on the road, the type of vehicle driven, and whether police at the accident believed drinking was involved. The process documented in NHTSA (2002) is followed for combining multiple imputations to find the status of the accident (BAC>0 or BAC=0). A detailed explanation is provided in the study performed by Adam and Cotti's (2012). To validate the data construction, the results from this 2012 study is replicated and presented in Table A4. The replicated results are similar to those of Adam and Cotti.

Measurement error would influence the results in Table 7 if higher cigarette prices increased non-alcohol-related accidents, which would lead to a rise in the probability of these accidents being falsely classified as alcohol-related. However, there is no possible reason to believe that higher cigarette prices would lead to an increase in non-alcohol-related accidents. If anything, increases in cigarette prices are likely to decrease non-alcohol-related accidents due to increased concentration in driving, resulting from driver reducing their smoking rate due to higher cigarette prices. Moreover, the findings that higher cigarette prices tend to increase alcohol-related driving fatalities, but have a negative impact on non-alcohol-related fatalities, implies that the results are not solely determined by the changes in driving conditions in the states that face an increase in cigarette prices.

Table A1. Including Smoke-Free Air Laws

	bar bans		workplace bans		restaurant bans		total restrictions	
	prevalence	OLS on drinkers	prevalence	OLS on drinkers	prevalence	OLS on drinkers	prevalence	OLS on drinkers
real cigarette price	0.0043	-0.0277	0.0039	-0.0296	0.0027	-0.0281	0.0027	-0.0285
	(0.0214)	(0.0383)	(0.0215)	(0.0396)	(0.0215)	(0.0376)	(0.0218)	(0.0394)
real beer price	-0.0048	0.0073	-0.0046	0.0072	-0.0046	0.0076	-0.0048	0.0077
	(0.0051)	(0.0076)	(0.0052)	(0.0076)	(0.0052)	(0.0075)	(0.0052)	(0.0076)
Post MSA* real	-0.0033	0.0633*	-0.0010	0.0715**	0.0023	0.0660*	0.0004	0.0712**
cigarette price	(0.0205)	(0.0346)	(0.0204)	(0.0349)	(0.0209)	(0.0334)	(0.0210)	(0.0347)
bar bans	0.0066	0.0429**						
	(0.0091)	(0.0212)						
workplace bans			-0.0070	0.0167				
			(0.0087)	(0.0189)				
restaurant bans					-0.0176	0.0360*		
					(0.0115)	(0.0198)		
total restrictions							-0.0030	0.0029
							(0.0022)	(0.0038)
N	165,804	94,432	165,804	94,432	165,804	94,432	165,804	94,432
r2	0.1293	0.1272	0.1293	0.1271	0.1294	0.1272	0.1294	0.1271

Note: The dependent variable for the first part model is drinking status (1=current drinker) and for the second part is the log of the number of drinks consumed per month given that he/she is a current drinker. Additionally, models control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, alcohol importance, alcohol-related driving fatalities, year fixed effects, whether keg information is required, number of fake IDs counts, mandatory training, training incentives, exceptions, Sunday bans, and state fixed effects. Robust standard errors clustered by states are reported in parenthesis. * indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table A2. Dividing Smokers and Non-smokers

	Never Smoked		*Smoked*	
	prevalence	OLS on drinker but not smokers	prevalence	OLS on drinkers and smokers
real cigarette price	-0.0068	-0.0175	0.0026	-0.0817
	(0.0265)	(0.0434)	(0.0209)	(0.0683)
Post MSA*real cigarette price	0.0132	0.0587	-0.0017	0.1518**
	(0.0266)	(0.0388)	(0.0172)	(0.0575)
real beer price	-0.0069	0.0030	-0.0008	0.0104
	(0.0062)	(0.0103)	(0.0035)	(0.0101)
effect after the MSA	0.0064	0.0412**	0.0009	0.0701***
	(0.0072)	(0.0172)	(0.0078)	(0.0184)
N	105,861	52,898	59,943	41,534
r2	0.1439	0.1331	0.1166	0.1393

Note: The dependent variable for the first part model is drinking status (1=current drinker) and for the second part is the log of the number of drinks consumed per month given that he/she is a current drinker. Additionally, models control for income, age, gender, race, employment status, marital status, state's level of percent dry, number of liquor outlets, alcohol importance, alcohol-related driving fatalities, year fixed effects, whether keg information is required, number of fake IDs count, mandatory training, training incentives, exceptions, Sunday bans, and state fixed effects. Robust standard errors clustered by states are reported in parenthesis. * indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

Table A3. Results from the Replication of Adam and Cotti's (2012) Results

Panel A (replicated results)	(1)	(2)	(3)	(4)
	OLS with Transformed Dependent Variable	NLS	WLS Transformed Dependent Variable	Weighted NLS
Minimum wage (2006 dollars)	0.043***	0.036***	0.039***	0.032***
	(0.013)	(0.014)	(0.009)	0.010
Beer tax (2006 dollars)	-0.343***	-0.238***	-0.342***	-0.221***
	(0.040)	(0.040)	(0.060)	(0.040)
Panel B (Adam and Cotti's results)	(1)	(2)	(3)	(4)
	OLS with Transformed Dependent Variable	NLS	WLS Transformed Dependent Variable	Weighted NLS
Minimum wage (2006 dollars)	0.046**	0.040**	0.030**	0.032**
	(0.012)	(0.012)	(0.007)	(0.009)
Beer tax (2006 dollars)	-0.378**	-0.303**	-0.338**	-0.290**
	(0.033)	(0.052)	(0.066)	(0.032)

Note: The models also include the log of non-alcohol related accidents (16-to-20-year olds), log of the population, BAC law of 0.08, log of per capita personal income, unemployment rate (16-to-20-year olds), and state and year fixed effects. Robust standard errors clustered by state are presented in parenthesis. * indicates p<0.10; ** indicates p<0.05; and *** indicates p<0.01.

How Efficient are the Current U.S. Alcohol Taxes?

Abstract

From a Pigovian framework, alcohol taxes should cover the external costs associated with alcohol consumption in order to avoid market failures. However, the real prices and taxes on alcohol in the U.S. have declined over recent decades. This paper examines the status of current alcohol taxes in the U.S. by questioning how far away the present alcohol taxes are from the optimal taxes. I calculate the price elasticity of alcohol consumption by utilizing recent tax changes and using data from the Behavioral Risk Factor Surveillance System. 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. An estimate from the benchmark model suggests that an optimal level of alcohol tax is 39 percent of the price per drink. After making an adjustment to the probability of alcohol-related diseases, I conclude that the optimal tax is 14 percent of the price per drink. Even the conservative estimates suggest that heavy drinkers do not pay their way and current alcohol taxes comprise only 5 percent of the external costs.

Key Words: Externality, Alcohol Taxation, Efficiency

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 alcohol 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 2005 to 2012. 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 borrow 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 alcohol taxes. The level of alcohol taxes in 2009 at $0.025 per drink covers approximately 5 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 alcohol taxes is $0.57 per drink. After making an adjustment to the probability of a heavy drinker suffering from ALD, the findings suggest $0.22 per drink as an optimal level of alcohol taxes. The level of alcohol taxes per drink in 2009 comprises a mere 11 percent of the optimal estimate. 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 fails to include 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 seminal paper (1989). To begin, I assume that there are two types of consumers — moderate drinks and heavy drinkers who are more liable to create alcohol-related risks. Figure 1 shows the demand schedule for the 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. Given this fact, this study focuses on beer taxes.

The assumption of a competitive market is that higher alcohol taxes are fully passed through as the alcohol price. Although Kenkel (2005) provides evidence that alcohol taxes are more than fully passed through as prices in Alaska, clarity is yet to be attained due to the concern of external validity and lack of a control group in that study. 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. [57]

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[57] Two main advantages for using taxes in favor of prices are: 1) Taxation is a key policy instrument; and 2) Taxes reduce an issue of measurement error present in prices, which can downward bias the estimate of price elasticity.

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 considered. Assuming that taxes are fully passed through as prices, 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 yields

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

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 $X'_B = x_n * n$. 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 2005 to 2012. 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 and the average number of drinks a respondent consumes while he/she drinks. To capture the overall drinking behavior, the number of drinks a person consumes per month is used as the dependent variable in my study. 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. While performing my empirical analysis, the top 2 percent of monthly drinks consumed is deleted unless mentioned, limiting the highest number of monthly drinks to 150.

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 1A and 1B). 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, wine, and spirit 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 2005 to 2012, nine states and the District of Columbia increased beer taxes. Figure 2 shows the trend in real beer taxes per gallon converted to 2012 dollars for the group of states that experienced tax changes and those states without tax change. Prior to 2009, the group that experienced tax changes had lower beer taxes than the group that did not experience a change in tax. Starting in 2009, the average tax amount for the group that experienced a tax change is greater than those who had no change. The difference in beer taxes between these groups further expands in 2012, suggesting the presence of within-state variation in beer taxes.

3B. Identification Strategy

I use the within-state variation in beer taxes occurring over time to identify the effect of higher alcohol taxes on alcohol consumption. Due to the high volume of non-drinkers in my model, I restrict my analysis to moderate and heavy drinkers. The basic specification can be written as follows:

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

where A is the number of drinks consumed by an individual i per month, surveyed in year t, and from state s, α is the constant, tax is the real beer tax converted to 2012 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. η and θ_s are the state fixed effects. As an attempt to control for the time-varying characteristics of states, the specification includes a state-specific linear time trend given by λ_t. The state-specific linear time trend captures any other linear state specific changes such as culture and sentiments. Robust standard errors clustered at the state level are presented.

Since alcohol-related externalities are prevalent among the heavy or risky drinkers, equation (6) is estimated for two types of drinkers: 1) Moderate drinkers or low risk drinkers; and 2) Heavy or risky drinkers. Referring to the definition given by the National Institute on Alcohol Abuse and Alcoholism, moderate drinking is defined as the consumption of more than 1 drink per month but below 5 drinks for men and below 4 drinks for women per occasion of drinking.[58] Similarly, males consuming more than 4 drinks and females consuming more than 3 drinks in one sitting are defined as risky or heavy drinkers. Equation (5) is estimated by gender and 4 different

[58] http://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking

age groups: 1) 18 to 25 year olds; 2) 25 to 34 year olds; 3) 35 to 44 year olds; and 4) 45 year olds and older. Such an age division is performed for three primary reasons: 1) Statistics pertaining to alcohol-related incidences suggest that young adults are more prone to create alcohol-related external costs; 2) The elasticity of demand is potentially higher for young adults due to the absence of an established pattern of habit; and 3) This study estimates the lifetime cost of heavy drinking, which is discounted to the age of 18. Hence, it is important to know the estimate of elasticity pertaining to young adults.

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

Table 2 presents the results for less risky drinkers where the findings shows the effect of higher alcohol prices on the log of monthly alcohol consumption. The results can be directly referred to as conditional price elasticity — pertaining to only those who participated in drinking under the assumption that taxes are fully passed through as prices. The estimation is further divided by four age groups: 1) 18 to 24 year olds; 2) 24 to 34 year olds; 3) 35 to 44 year olds; and 4) 45 year olds and up.[59] Panel A of Table 2 pertains to males consuming less than 5 drinks in one typical sitting and Panel B refers to females drinking less than 4 drinks in one typical sitting.

Referring to Panel A (male group), the coefficient on the log of the beer tax is negative for 18 to 24 year olds. The findings suggest that the conditional tax elasticity is -0.148 for the less risky drinkers and is statistically significant at a 5 percent level. For the rest of the age groups in the analysis, the coefficient on the log of the beer tax is close to 0 and is statistically insignificant. The coefficients on the log of the beer tax presented in Panel B shows that higher beer taxes are associated with a reduction in the number of drinks consumed for 18 to 24 year olds females who are moderate drinkers and the coefficients are significant at a 1percent level. Both Panel A and

[59] The reasoning for such a division is discussed in Section II of this paper.

Panel B suggest that young adults are responsive to higher alcohol taxes; whereas, older adults are not responsive.

Table 3 presents the results after estimating equation (2) for both males and females using the same age groups seen in Table 2. The focus of analysis at this point are males who reported drinking more than 4 drinks in a typical sitting and females who reported having consumed more than three drinks in one sitting. As in Table 2, the coefficient on the log of taxes in Table 3 can be viewed as conditional elasticities (given that a person participates in risky drinking) and completely focuses at the internal margin.

The results in Panel A show that 18 to 24 year old male risky drinkers are sensitive to higher beer taxes. The conditional tax elasticity, given that someone participates in heavy drinking for this age group, is -0.231 and is significant at a 1percent level. This finding favors alcohol taxation as one of the major tools to control alcohol-related externalities, such as highway fatalities and crime, as these externalities are highest among this age group and are mainly a result of heavy/binge drinking. However, conditional tax elasticities for other age groups are not statistically significant. Panel B shows that the conditional tax elasticity for females aged 25 to 34 is -0.229, but is insignificant at conventional levels. Such results can be explained by two main reasons: 1) Young adults might not yet have an established pattern of habits; and 2) Young adults have lower income relative to older groups, which could make them more tax sensitive.

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 4, 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 sub-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.

4A. 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.

4A.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.[60]

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

[60] 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.

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.[61]

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 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

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[61] 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.

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. 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.

4A.2. Results

Table 5 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 6.1 shows the life expectancy at age 18 for all three groups. Compared to non-heavy drinkers, heavy drinkers on average die 6 years earlier; 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 6.2.

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.[62] 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.

4B. 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.

4B.1. Data

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

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[62] 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.

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 (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).

4B.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.[63] 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 7 presents descriptive statistics from the MEPS data for years 2000 to 2012 at a given point in time. Not surprisingly, the results from Table 7 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 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.

[63] 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.

According to the National Vital Statistics Report of the NCHS, 30,627 deaths occurred in 2009 due to liver cirrhosis. Table 8.14 breakdown of total expenses per event according to various sources of payments per event by using the 30,627 cases of liver cirrhosis is shown in Table 8.1. 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 8.2 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 8.3. 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).[64]

4C. 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.

4C.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).[65]

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

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[64] 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.

[65] 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).

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.

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). That 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.

4D. Effects on Social Security

The social security fund outlays are expected to exceed revenue by 2016 and the fund it is estimated that the fund will be depleted by 2038 (Board of Trustees 2001; Concord Coalition, 2001). 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.

4E. 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.[66]

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 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 6.1. The total alcohol taxes paid are then calculated by multiplying the total number of drinks per lifetime by the tax per drink in 2009 of $0.025.

Table 9 shows that the external cost of heavy drinking per drink is $1.332 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 $0.496. The estimates from all the columns in Table 3 are entered into equation (4) to estimate the optimal tax rate per price of one drink. For the calculation, I use the 2009 price level (per drink) and the elasticity estimates presented in Table 1

[66] 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.

and 2 for 18 to 24 year olds.[67] The optimal tax per drink is estimated as 39 percent, 21 percent, and 14 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 estimates by allowing the probability of liver cirrhosis to vary. The tax estimates range from 21 percent to 12 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. Manning et al.'s study in 1989 assumes that a heavy drinker or a smoker internalizes the costs imposed to family members. 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.[68] 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 3 cents per drink in tax. If alcohol taxes are to be used as a medium to allow heavy or risky drinkers to internalize the

[67] 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.

[68] 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.

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?

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 bt 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 14 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.

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Figure 1

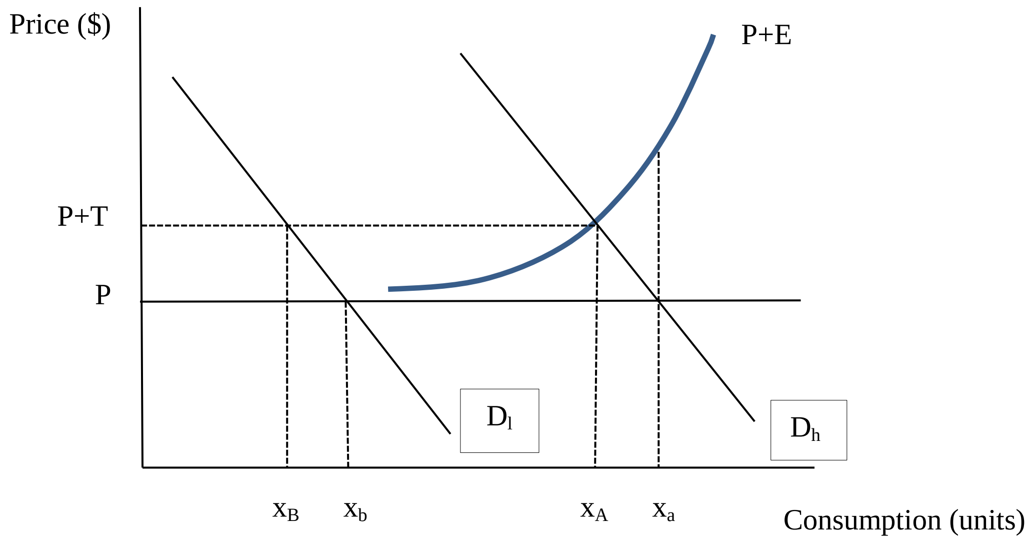


Figure 2

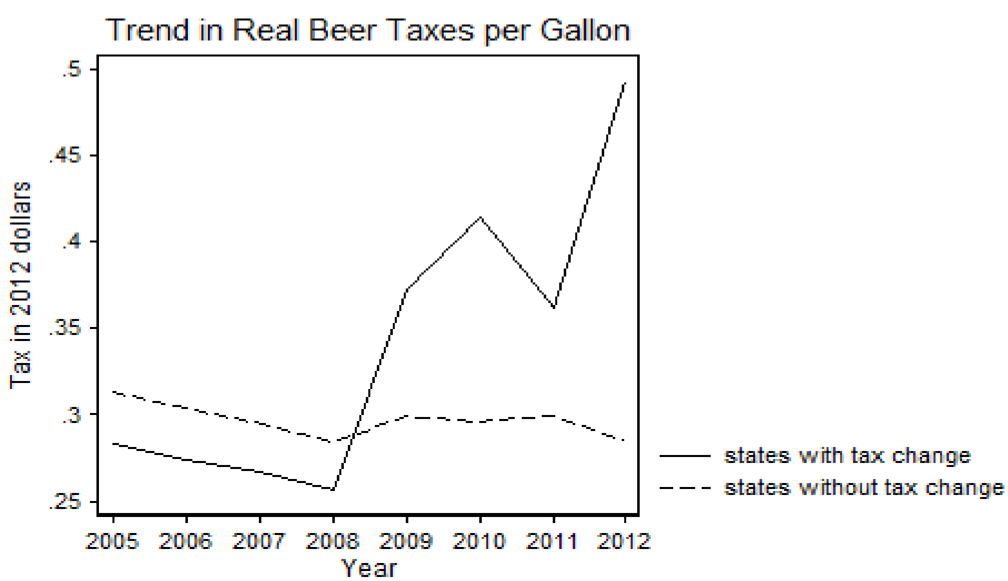
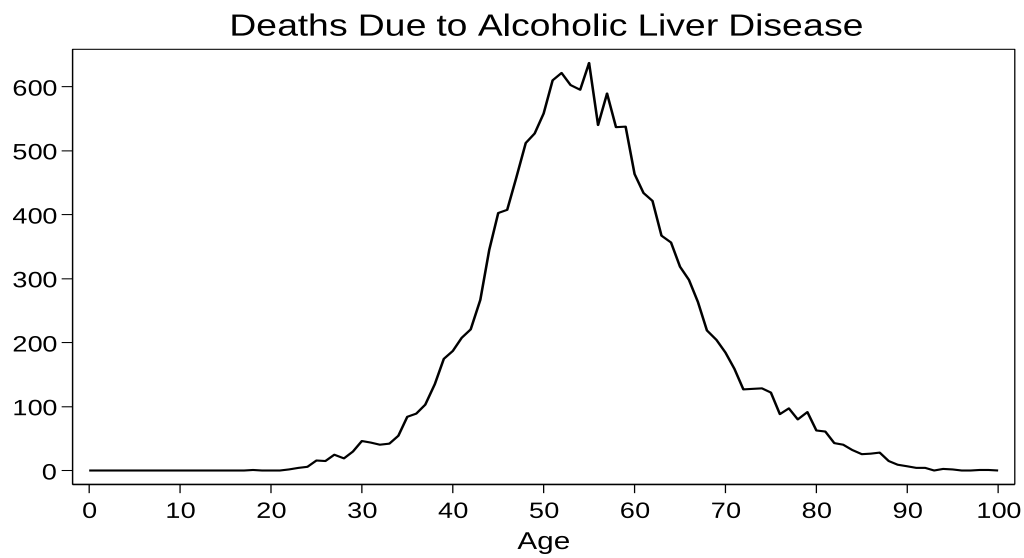


Figure 3



Note: Data Source NCHS (2009)

Figure 4

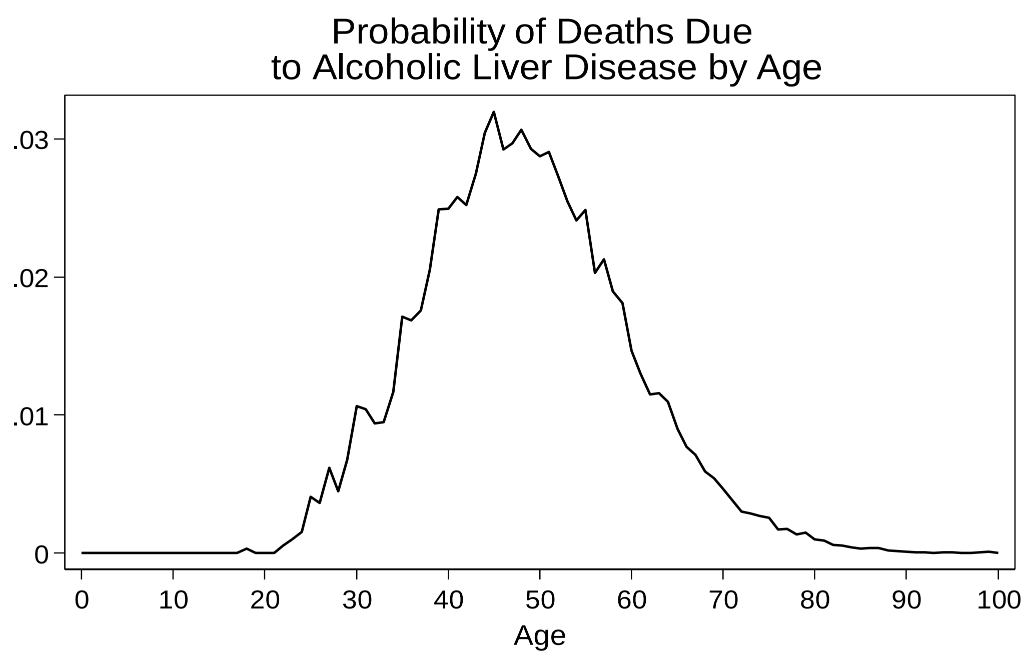


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Figure 5

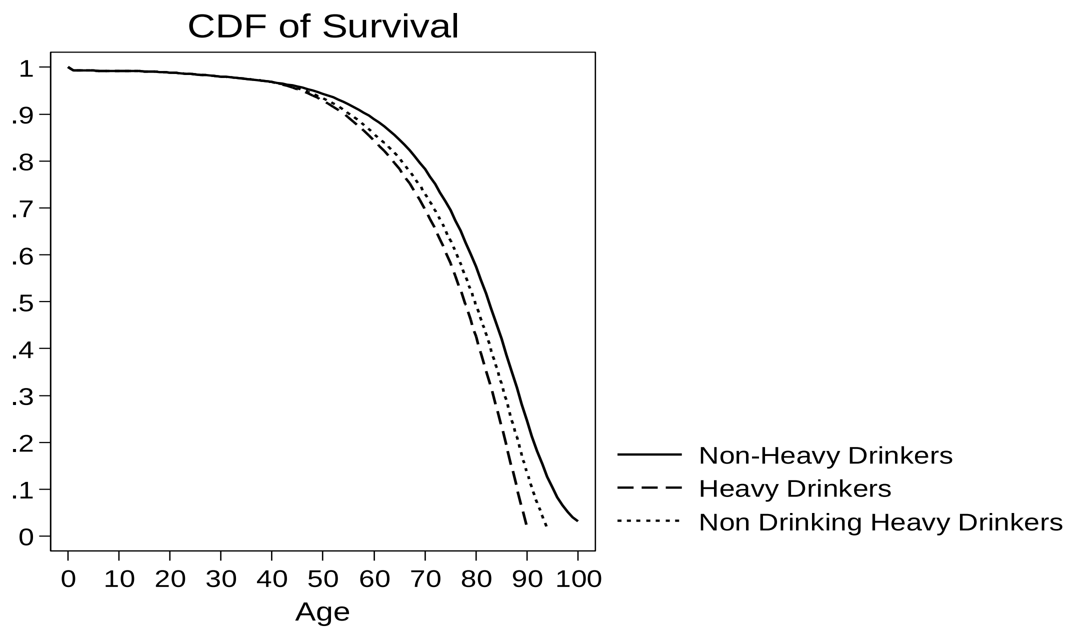

Figure 6

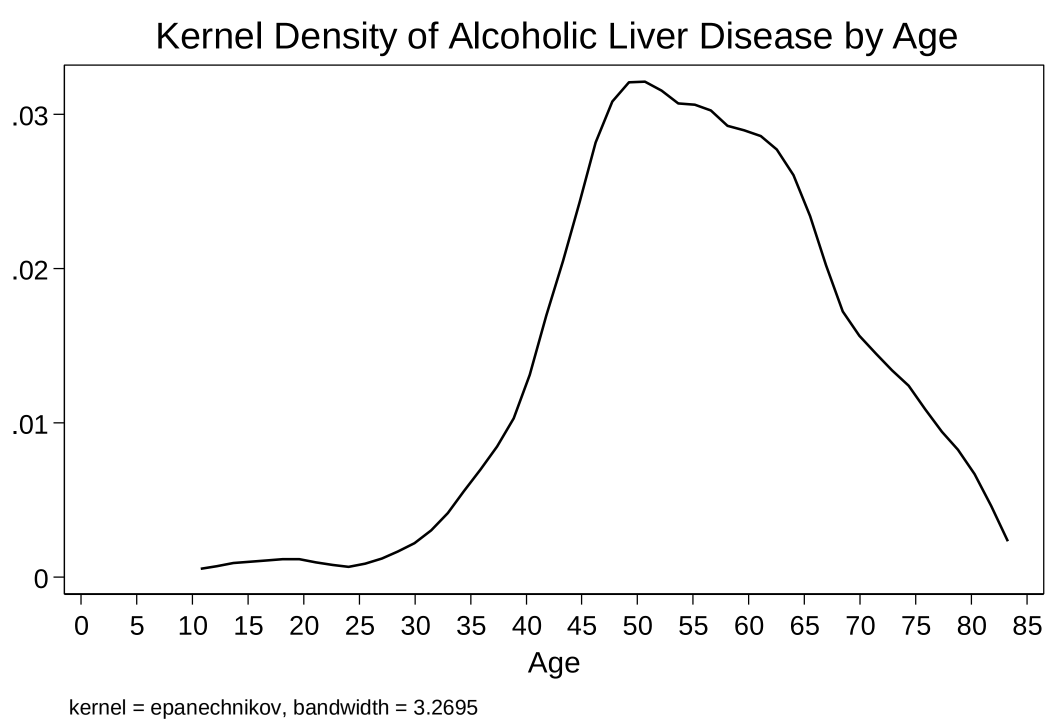

Figure 7

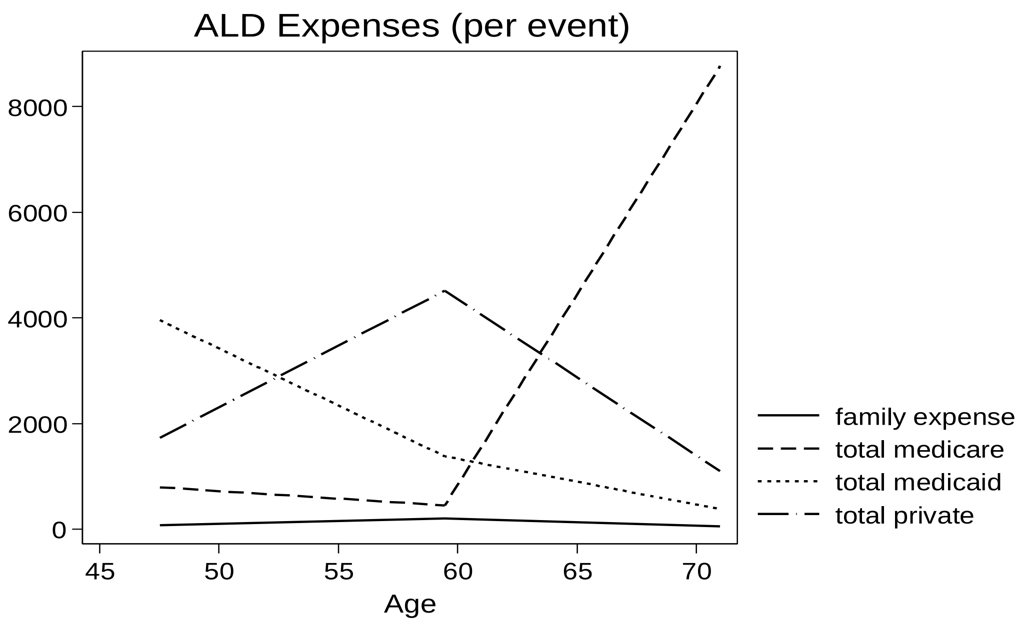

Figure 8

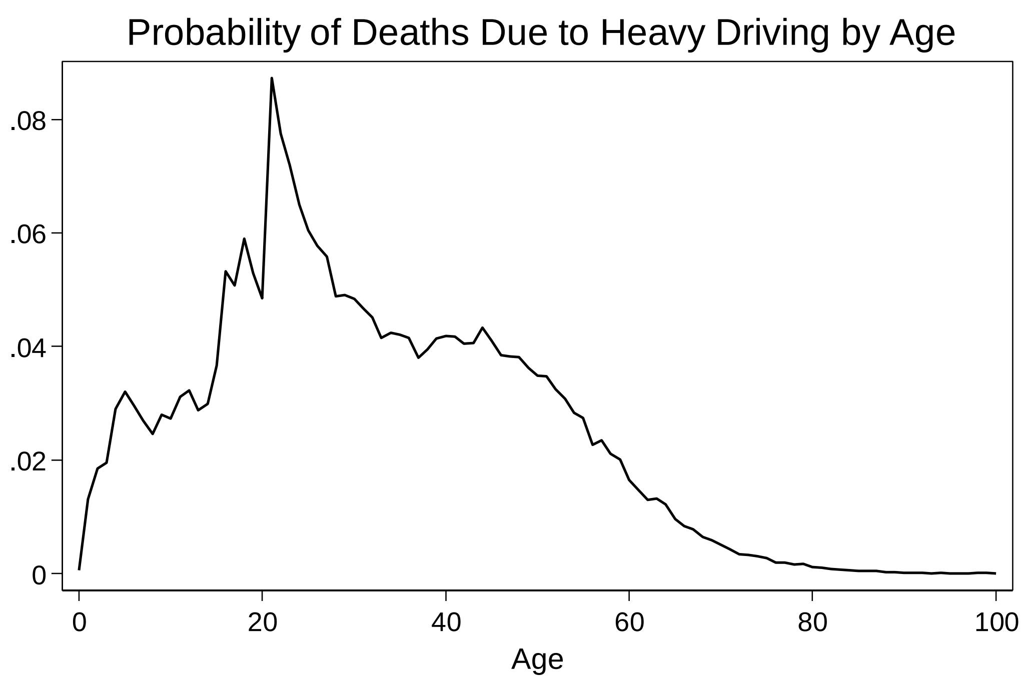

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Figure 9

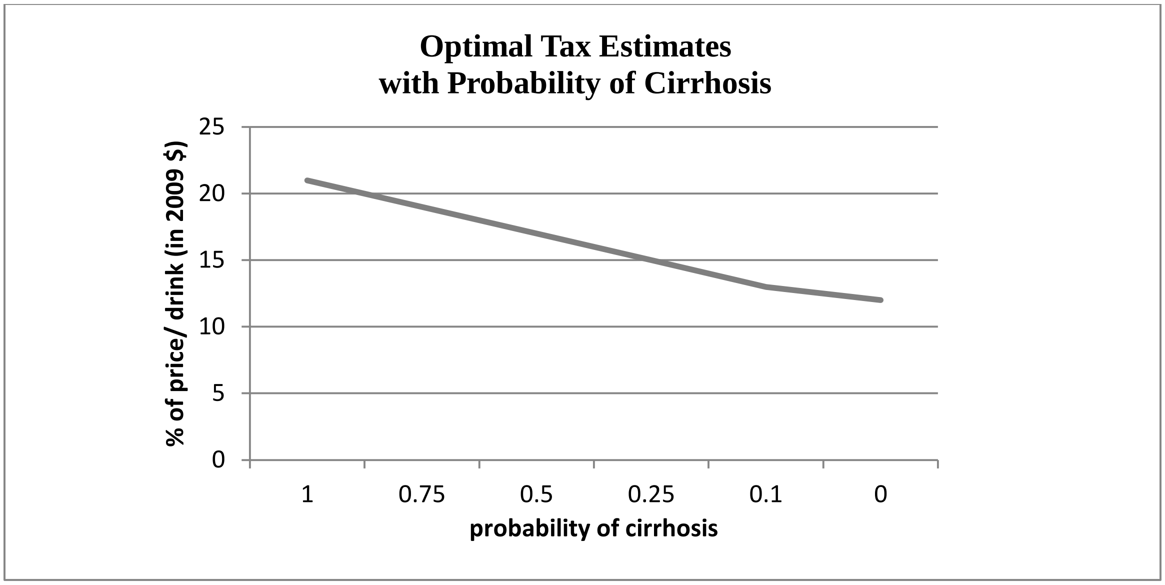
Optimal Tax Estimates
with Probability of Cirrhosis
% of price/ drink (in 2009 $)
25
20
15
10
5
0
1
0.75
0.5
0.25
0.1
0
probability of cirrhosis

Table 1A. Summary Statistics

Variable	18 to 24 year olds Male (N=37,876) Mean	Std. Dev.	Female (N=42,437) Mean	Std. Dev.	24 to 34 year olds Male (N=90,592) Mean	Std. Dev.	Female (N=123,276) Mean	Std. Dev.
current drinker	0.776	0.417	0.743	0.437	0.880	0.325	0.812	0.391
binge	0.325	0.468	0.170	0.376	0.253	0.434	0.108	0.310
drinks per month	20.834	28.793	10.795	18.058	20.684	26.047	9.419	14.923
log(drinks per month)	2.614	1.286	1.980	1.210	2.535	1.209	1.812	1.140
log(real beer tax)	-1.503	0.754	-1.496	0.758	-1.518	0.754	-1.517	0.754
percent dry	1.868	6.689	2.068	6.960	1.954	6.954	2.044	6.938
real cigarette tax	1.326	0.849	1.290	0.841	1.275	0.825	1.276	0.824
keg deposit	4.543	14.041	4.471	14.040	4.423	14.161	4.296	13.877
sunday ban	0.223	0.416	0.226	0.419	0.222	0.416	0.226	0.418
age	21.234	1.998	21.479	1.957	29.892	2.833	29.949	2.809
married	0.099	0.298	0.172	0.377	0.552	0.497	0.561	0.496
divorced	0.007	0.086	0.016	0.124	0.050	0.218	0.075	0.263
widowed	0.001	0.029	0.001	0.034	0.002	0.044	0.005	0.068
separated	0.007	0.080	0.014	0.118	0.017	0.127	0.032	0.175
never married	0.800	0.400	0.699	0.459	0.306	0.461	0.259	0.438
unmarried couple	0.081	0.273	0.096	0.295	0.071	0.257	0.067	0.251
refused	0.005	0.072	0.003	0.050	0.003	0.051	0.002	0.043
income <$10,000	0.066	0.248	0.093	0.290	0.027	0.162	0.044	0.206
10<=income<15 (000)	0.052	0.223	0.063	0.243	0.027	0.163	0.042	0.200
15<=income<20 (000)	0.085	0.279	0.095	0.293	0.051	0.220	0.062	0.242
20<=income<25 (000)	0.101	0.301	0.108	0.310	0.074	0.262	0.081	0.273
25<=income<35 (000)	0.115	0.320	0.110	0.312	0.111	0.314	0.112	0.316
35<=income<50 (000)	0.119	0.324	0.113	0.316	0.164	0.370	0.155	0.362
50<=income<75 (000)	0.101	0.302	0.092	0.289	0.197	0.398	0.181	0.385
>=75,000	0.157	0.364	0.117	0.322	0.286	0.452	0.254	0.435
income missing	0.202	0.402	0.209	0.407	0.062	0.242	0.068	0.252
no school	0.001	0.031	0.001	0.029	0.001	0.032	0.001	0.025
elementary school	0.011	0.105	0.007	0.085	0.015	0.123	0.012	0.111
some high school	0.101	0.301	0.082	0.274	0.052	0.222	0.044	0.205
high school graduates	0.379	0.485	0.309	0.462	0.256	0.436	0.200	0.400
some college	0.354	0.478	0.397	0.489	0.262	0.440	0.290	0.454
college graduate or	0.153	0.360	0.204	0.403	0.413	0.492	0.452	0.498

more								
education missing	0.001	0.031	0.001	0.026	0.001	0.033	0.001	0.026
employed for wages	0.541	0.498	0.497	0.500	0.769	0.422	0.645	0.478
self-employed	0.052	0.222	0.025	0.157	0.097	0.296	0.057	0.232
unemployed (>1 year)	0.036	0.185	0.034	0.181	0.024	0.154	0.027	0.162
unemployed (<1 year)	0.088	0.283	0.065	0.247	0.047	0.211	0.039	0.193
homemaker	0.002	0.040	0.065	0.247	0.005	0.068	0.152	0.359
enrolled in school	0.263	0.440	0.292	0.455	0.038	0.192	0.054	0.226
retired	0.001	0.038	0.001	0.030	0.001	0.034	0.001	0.023
unable to work	0.013	0.114	0.017	0.130	0.017	0.130	0.023	0.151
employment missing	0.004	0.065	0.003	0.057	0.002	0.047	0.002	0.041
state unemployment rate	6.785	2.281	6.717	2.248	6.532	2.279	6.613	2.288

Table 1B. Summary Statistics

	35 to 44 year olds				45 years and up			
	Male (N=131,097)		Female (N=179,860)		Male (N=554,989)		Female (N=771,978)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
current drinker	0.878	0.328	0.829	0.376	0.805	0.396	0.702	0.458
binge	0.185	0.388	0.072	0.259	0.085	0.278	0.026	0.159
drinks per month	19.238	25.048	9.781	15.205	19.180	26.141	9.511	16.115
log(drinks per month)	2.438	1.226	1.813	1.157	2.466	1.310	1.873	1.255
log(real beer tax)	-1.530	0.744	-1.528	0.738	-1.521	0.754	-1.523	0.750
percent dry	1.787	6.597	1.882	6.639	1.802	6.552	1.933	6.642
real cigarette tax	1.291	0.816	1.300	0.821	1.332	0.825	1.344	0.835
keg deposit	4.468	14.150	4.547	14.185	4.655	14.310	4.786	14.443
sunday ban	0.214	0.410	0.215	0.411	0.206	0.404	0.213	0.409
age	39.682	2.856	39.694	2.857	62.285	10.781	62.939	11.332
married	0.691	0.462	0.665	0.472	0.660	0.474	0.516	0.500
divorced	0.105	0.306	0.138	0.345	0.146	0.353	0.172	0.378
widowed	0.004	0.067	0.012	0.107	0.081	0.272	0.215	0.411
separated	0.021	0.145	0.035	0.183	0.016	0.125	0.017	0.129
never married	0.143	0.350	0.118	0.322	0.080	0.271	0.062	0.242
unmarried couple	0.034	0.181	0.031	0.175	0.015	0.123	0.015	0.120
refused	0.002	0.047	0.002	0.047	0.002	0.046	0.003	0.057
income <$10,000	0.021	0.144	0.032	0.175	0.026	0.160	0.038	0.191
10<=income<15 (000)	0.020	0.140	0.029	0.167	0.035	0.184	0.050	0.217
15<=income<20	0.034	0.182	0.042	0.200	0.048	0.214	0.063	0.242

(000)								
20<=income<25 (000)	0.049	0.215	0.055	0.228	0.069	0.254	0.082	0.274
25<=income<35 (000)	0.072	0.259	0.077	0.266	0.100	0.300	0.105	0.307
35<=income<50 (000)	0.129	0.335	0.129	0.335	0.147	0.354	0.136	0.343
50<=income<75 (000)	0.185	0.389	0.179	0.384	0.167	0.373	0.145	0.353
>=75,000	0.433	0.496	0.390	0.488	0.322	0.467	0.234	0.423
income missing	0.056	0.231	0.069	0.253	0.085	0.279	0.148	0.355
no school	0.001	0.029	0.001	0.026	0.001	0.029	0.001	0.029
elementary school	0.015	0.122	0.011	0.105	0.024	0.152	0.019	0.135
some high school	0.040	0.196	0.032	0.176	0.042	0.202	0.044	0.205
high school graduates	0.244	0.430	0.194	0.396	0.263	0.440	0.291	0.454
some college	0.243	0.429	0.276	0.447	0.242	0.428	0.285	0.451
college graduate or more	0.456	0.498	0.485	0.500	0.427	0.495	0.360	0.480
education missing	0.001	0.030	0.001	0.029	0.001	0.036	0.001	0.038
employed for wages	0.757	0.429	0.657	0.475	0.384	0.486	0.378	0.485
self-employed	0.140	0.347	0.089	0.284	0.137	0.344	0.072	0.258
unemployed (>1 year)	0.021	0.144	0.024	0.154	0.022	0.147	0.022	0.146
unemployed (<1 year)	0.035	0.183	0.030	0.171	0.020	0.140	0.017	0.130
homemaker	0.005	0.073	0.145	0.352	0.002	0.043	0.089	0.285
enrolled in school	0.007	0.085	0.016	0.127	0.001	0.038	0.003	0.054
retired	0.004	0.061	0.002	0.042	0.377	0.485	0.355	0.478
unable to work	0.029	0.169	0.035	0.184	0.053	0.225	0.062	0.240
employment missing	0.002	0.043	0.001	0.037	0.002	0.043	0.002	0.049
state unemployment rate	6.565	2.317	6.635	2.307	6.863	2.329	7.000	2.279

Table 2. Effect of Higher Taxes on Alcohol Consumption (Moderate Drinkers)

Panel A (< 5 drinks, male)	18 to 24 year olds OLS	24 to 34 year olds OLS	35 to 44 year olds OLS	45 years and older OLS
log(real beer tax)	-0.1484**	-0.0231	0.082	0.0313
	(0.07)	(0.08)	(0.06)	(0.03)
percent dry	-0.0093	0.0065	0.0215	-0.003
	(0.03)	(0.02)	(0.02)	(0.01)
keg deposit	-0.0002	-0.0005	0.0035**	0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Sunday ban	0.055	0.0209	-0.0672	0.0531*
	(0.10)	(0.06)	(0.05)	(0.03)
N	20,456	64,619	100,393	434,494
r2	0.073	0.0408	0.0257	0.0212
Panel B (< 4 drinks, female)	18 to 24 year olds OLS	24 to 34 year olds OLS	35 to 44 year olds OLS	45 years and older OLS
log(real beer tax)	-0.1698***	0.0401	-0.0606	-0.017
	(0.05)	(0.06)	(0.05)	(0.02)
percent dry	0.0075	0.0307*	0.004	0.0071
	(0.01)	(0.02)	(0.01)	(0.01)
keg deposit	-0.0007	-0.0001	0.0018*	0.0004
	(0.00)	(0.00)	(0.00)	(0.00)
Sunday ban	0.0337	-0.0498	-0.0118	0.0226
	(0.09)	(0.05)	(0.04)	(0.02)
N	27,177	92606	142202	549033
r2	0.0674	0.0516	0.0323	0.0362

Note: The dependent variable is the log of drinks consumed per month given that an individual is a moderate drinker. A moderate drinker is defined as someone drinking more than one drink per month but less than 5 drinks if male and 4 drinks if female per occasion. Additionally, models control for income, age, gender, race, employment status, marital status, cigarette taxes, percent dry, whether keg information is required, purchase bans on Sunday, unemployment rate, state fixed effects, year fixed effects, and state- specific linear time trends. Robust standard errors are clustered at state level and are presented in parenthesis. * indicates p<0.10,** indicates p<0.05; and *** indicates p<0.01.

Table 3. Effect of Higher Alcohol Taxes on Alcohol Consumption (Risky Drinkers)

Panel A (>4 drinks, male)	18 to 24 year olds OLS	24 to 34 year olds OLS	35 to 44 year olds OLS	45 years and older OLS
log(real beer tax)	-0.2308***	-0.1605	0.0304	-0.0189
	(0.068)	(0.145)	(0.158)	(0.109)
percent dry	-0.1197	0.006	0.0221	-0.0355
	(0.072)	(0.038)	(0.034)	(0.025)
keg deposit	-0.0061*	-0.0013	0.0009	-0.0013
	(0.003)	(0.003)	(0.003)	(0.002)
Sunday ban	0.0854**	-0.0047	-0.0654	-0.2083**
	(0.035)	(0.109)	(0.117)	(0.097)
N	8,954	15,102	14,650	26,169
r2	0.0482	0.0377	0.0295	0.0339
Panel A (>3 drinks, female)	18 to 24 year olds OLS	24 to 34 year olds OLS	35 to 44 year olds OLS	45 years and older OLS
log(real beer tax)	-0.12	-0.2291	-0.1612	-0.0189
	(0.206)	(0.155)	(0.171)	(0.109)
percent dry	0.0061	0.0369	-0.0172	-0.0355
	(0.057)	(0.039)	(0.041)	(0.025)
keg deposit	-0.0006	-0.0011	-0.0013	-0.0013
	(0.003)	(0.003)	(0.003)	(0.002)
Sunday ban	0.041	0.2195*	-0.0304	-0.2083**
	(0.156)	(0.114)	(0.133)	(0.097)
N	7,215	13,270	13,022	26,169
r2	0.0672	0.0484	0.0285	0.0339

Note: The dependent variable is the log of drinks consumed per month given that an individual is a moderate drinker. A moderate drinker is defined as someone drinking more than one drink per month but less than 5 drinks if male and 4 drinks if female per occasion. Additionally, models control for income, age, gender, race, employment status, marital status, cigarette taxes, percent dry, whether keg information is required, purchase bans on Sunday, unemployment rate, state fixed effects, year fixed effects, and state- specific linear time trends. Robust standard errors are clustered at state level and are presented in parenthesis. * indicates p<0.10,** indicates p<0.05; and *** indicates p<0.01.

Table 4. 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 5. 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 6.1 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 6.2 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 7. 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 8.1. 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 8.2. 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 8.3. 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 9. Effect of Heavy Drinking on Forgone Income Taxes

		Survival probability						
Age Group	Median Income	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 10. Taxes, Cost, and Contribution by a Heavy Drinker

	(1)	(2)	(3)
Costs			
Years of Life Lost	-57,552	-57,552	-57,552
Medicare and Medicaid	-53,909.4	-17,965	-3,593
Drunk Driving	-373	-373	-373
Effects on Social Security	*12,01.75*	*12,01.75*	*12,01.75*
Forgone Income Taxes	-923	-923	-923
Contribution			
*Lifetime Medicare Taxes**	*28,910*	*28,910*	*28,910*
Total Number of Drinks	60,225	60,225	60,225
Total Alcohol Tax Paid	*1,505.625*	*1,505.625*	*1,505.625*
Number of Visits	15	4	4
Probability of Liver Cirrhosis	1	1	0.2
Total External cost of Heavy Drinking	-81,140	-45,196	-30,824
Total External Cost of Heavy Drinking per Drink	$1.347	$0.750	$0.512

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.

Appendix

Survival Probability by Age

Age	Non-Heavy Drinkers	Heavy Drinkers	Non-Drinking Heavy Drinkers
0	1	1	1
1	0.9936349	0.9936349	0.9936349
2	0.9932402	0.9932402	0.9932402
3	0.9929754	0.9929754	0.9929754
4	0.9927698	0.9927698	0.9927698
5	0.9926144	0.9926144	0.9926144
6	0.9924692	0.9924692	0.9924692
7	0.9923431	0.9923431	0.9923431
8	0.9922262	0.9922262	0.9922262
9	0.992119	0.992119	0.992119
10	0.9920315	0.9920315	0.9920315
11	0.9919439	0.9919439	0.9919439
12	0.9918569	0.9918569	0.9918569
13	0.9917311	0.9917311	0.9917311
14	0.9915466	0.9915466	0.9915466
15	0.9912749	0.9912749	0.9912749
16	0.9909185	0.9909185	0.9909185
17	0.9904925	0.9904925	0.9904925
18	0.9899896	0.9899896	0.9899896
19	0.9894158	0.9894158	0.9894158
20	0.988772	0.988772	0.988772
21	0.9880491	0.9880491	0.9880491
22	0.9872828	0.9872828	0.9872828
23	0.9864624	0.9864624	0.9864624
24	0.9856087	0.9856087	0.9856087
25	0.9847487	0.9847487	0.9847487
26	0.9838867	0.9838867	0.9838867
27	0.9830213	0.9830213	0.9830213
28	0.9821447	0.9821447	0.9821447
29	0.9812521	0.9812521	0.9812521
30	0.9803314	0.9803314	0.9803314
31	0.9793826	0.9793826	0.9793826
32	0.9784063	0.9784063	0.9784063
33	0.9773872	0.9773872	0.9773872
34	0.9763191	0.9763191	0.9763191
35	0.9752043	0.9752043	0.9752043
36	0.9740402	0.9740402	0.9740402

37	0.9728005	0.9728005	0.9728005
38	0.9714817	0.9714817	0.9714817
39	0.9700692	0.9700692	0.9700692
40	0.9685559	0.9685559	0.9685559
41	0.9669213	0.9659241	0.9662847
42	0.9651536	0.9630782	0.9638287
43	0.9632201	0.9599652	0.9611422
44	0.9610996	0.9565513	0.9581959
45	0.9587798	0.9528163	0.9549727
46	0.9562549	0.9487514	0.9514647
47	0.953514	0.9443384	0.9476563
48	0.9505458	0.9395598	0.9435323
49	0.9473098	0.9343496	0.939036
50	0.9437678	0.928647	0.9341147
51	0.9399021	0.9225391	0.9286787
52	0.9356972	0.9158953	0.9227657
53	0.9311624	0.9087303	0.9163888
54	0.9263116	0.9010662	0.9095678
55	0.9211426	0.8928992	0.9022992
56	0.9156388	0.8842032	0.8945597
57	0.9097596	0.874914	0.8862923
58	0.9034976	0.8650202	0.8774868
59	0.896775	0.8543984	0.8680334
60	0.8895916	0.8430485	0.8579321
61	0.8818853	0.832568	0.8488141
62	0.8736375	0.821351	0.8390552
63	0.8648303	0.8093731	0.8286344
64	0.8554071	0.7965576	0.8174849
65	0.8453131	0.7828299	0.8055418
66	0.8344254	0.7680227	0.7926595
67	0.8226714	0.7520372	0.7787521
68	0.810038	0.7348557	0.7638042
69	0.7965276	0.7164815	0.7478188
70	0.782178	0.696966	0.7308403
71	0.7668884	0.6769367	0.7132946
72	0.7505801	0.6555727	0.6945798
73	0.733211	0.6328193	0.6746477
74	0.714588	0.6084232	0.6532767
75	0.694658	0.5823148	0.6304057
76	0.6735138	0.5546158	0.6061414
77	0.6510949	0.5252471	0.5804145
78	0.6272522	0.4940132	0.5530536
79	0.6018982	0.4607994	0.5239583

80	0.5750765	0.4256631	0.4931789
81	0.5468833	0.3907035	0.4625543
82	0.517424	0.3541739	0.4305544
83	0.4865686	0.3159132	0.397038
84	0.454418	0.2760464	0.3621147
85	0.4211629	0.23481	0.3259917
86	0.3866432	0.1920055	0.288495
87	0.3514635	0.1483828	0.2502814
88	0.3160384	0.1044556	0.2118012
89	0.2808383	0.0608075	0.1735655
90	0.2464128	0.0181199	0.1361711
91	0.2132551	Na	0.1030134
92	0.1818994	Na	0.0716577
93	0.1528078	Na	0.0425661
94	0.1263762	Na	0.0161345
95	0.1029018	Na	Na
96	0.0825475	Na	Na
97	0.0653566	Na	Na
98	0.051223	Na	Na
99	0.039949	Na	Na
100	0.0312116	Na	Na