The effect of alcohol tax on alcohol consumption, drunk driving and binge drinking

Yekaterina V. Zelikman
Krannert School of Management
Purdue University
kzelima@purdue.edu

ABSTRACT
Americans spend over $90 billion dollars total on alcohol each year. While small amounts of alcohol have been found to be beneficial to a person’s health, moderate to large amounts of alcohol have been linked to many immediate and long-term side effects, ranging from violence and unconsciousness to liver failure and death. In this paper, we will examine how tax imposed on alcohol affects alcohol consumption, drunk driving, and binge drinking.

Keywords
Tax, Alcohol, Binge Drinking, Beer, Legislation

1. INTRODUCTION
Americans spend over $90 billion dollars total on alcohol each year [1]. While small amounts of alcohol have been found to be beneficial to a person’s health [2], moderate to large amounts of alcohol have been linked to many immediate and long-term side-effects, ranging from violence and unconsciousness to liver failure and death [3]. Frequent use of alcohol can become addicting and lead to a serious problem of alcoholism. Nearly 17.6 million adults in the United States are alcoholics or have alcohol related problems [4]. Another side-effect of overuse of alcohol is drunk-driving. With wider use of cars, alcohol related accidents and fatalities have been a cause for concern on our roadways. In fact, out of all vehicle accidents reported in 2005, 39% were attributed to alcohol use [5]. The US government has tried multiple strategies to help curtail excessive drinking and its effects. A notorious example of an extreme strategy was The Prohibition in the 1920’s. This strategy did
not work, as many started brewing their own alcohol, which, in fact, became even more
dangerous (as there ceased to be a health standard for alcohol production). Furthermore, the
prohibition actually caused alcohol consumption levels to rise [6]! The government also tried
to set a legal age limit of “21 and over” in exchange for highway funds for each state. Yet
underage drinking was not eliminated and continues to be a serious problem in our society.
Though this problem is harder to monitor since it cannot be tracked through alcohol sales,
tools such as surveys, police arrest records and hospital records have revealed that 10.8
million Americans, age 12-20, consume alcohol and 7.2 million engage in binge drinking [7].
Binge drinking, consuming 5 or more drinks in 30 minutes, is also a growing concern,
especially on college campuses.

One of the effective ways the American government has found to reduce these
problems is through taxation. Imposing federal and state taxes has changed many of the above
stated numbers. The government has divided the alcohol beverage industry into 3 parts: beer,
hard liquor and wine. Each type of alcohol is taxed differently at the state level on top of the
federal tax that was passed in 1991. It is the state’s responsibility to keep track of the tax and
decide when to renew it, yet many of the states have not been following the code. According
to 2006 statistics, 22 states have not raised their beer excise tax in 20 years [9], leading many
taxes to be ineffective as they are deflated by inflation.

Beer is usually the drink of choice and makes up the majority of the market. In 2005,
beer made up 85.8% of the total alcoholic beverage consumption [8]. Because beer is such a
big component of this market, this paper solely looks at the effects of beer excise taxes. This
will facilitate and standardize the data due to different taxation methods on different alcohol
types. In this thesis, I examine the different tax rates imposed by the states and identify a
relationship between beer sales tax and 4 variables: alcohol consumption, drunk driving, binge drinking and underage drinking. I also examine if these variables are significantly affected, both economically and statistically, by an increase in excise tax. My hypothesis is that it will cause all four to go down. After identifying these effects, I quantify the information to approximate the number of lives that could be saved in each category by raising taxes.

This topic is relevant to both federal and state policies and governments. There have been many research papers written on beer consumption, beer tax, drunk driving and underage drinking, but few have brought all these concepts together to make a specific argument and answer the question - should the government regulate these taxes more heavily?

In summary, this thesis will look at the effects of an increase in a beer state excise tax on variables such as alcohol consumption, drunk driving, binge and underage drinking. The purpose of this paper is to provide more information in the discussion of the beer excise tax system.

2. RELATED WORK

Over the years, many researchers have looked at alcohol related policies and their effect on various components of our society. Michael Grossman, a professor of economics at City University of New York, has done much research in the area of health policies among young adults, mainly concentrating on addictive behavior such as smoking and drinking. The concentration on this age group is very significant because it has been shown that the majority of addictive behaviors start early in life and, therefore, any policy that may prevent these behaviors might be the most effective way of reducing them in all the segments of the population [10]. Grossman claims that this is because youths have a more stringent budget
constraint and therefore are more price sensitive than adults. In effect, higher taxes would increase beer price and decrease underage consumption. Kenkel reported that the price elasticity of demand for 18 year olds and older is -.92, while it is -2.24 for persons in the 18-21 age range [11]. This supports Grossman’s claim that younger individuals are more price sensitive. I am skeptical of these numbers due to the uncertainty of the accuracy of the data. The use of alcohol by underage drinkers is hard to monitor since it is illegal for them to buy alcohol; therefore it cannot be recorded through alcohol sales. Grossman also relates his findings to drunk driving, claiming that a larger tax would have saved 1,660 lives per year in the 1982-88 periods.

In his papers, Grossman also makes a point about nominal vs. real tax rates (taxes adjusted for inflation). He claims that if the tax has been indexed to the rate of inflation, this policy would have reduced the number of high school seniors who drank frequently in the past year by 45 percent, the number who drank frequently in the past month by 43 percent and the number with at least one heavy drinking episode in the past two weeks by 18 percent. These effects are greater than the declines associated with the legal minimum drinking age of 21 [10].

Rober Brown, Todd Jewell and Jerrell Richer performed an interesting analysis on “dry” (prohibiting the sale of alcohol) and “wet” counties in Texas and its relationship to drunk driving. In their case, consumption consisted of two components: price of alcohol and transportation costs. If consumption was effected by the price, then transportation costs will keep people from driving to “wet” counties to buy alcohol, which in effect will reduce drunk driving. If, however, consumption is unaffected by price, prohibition only increases the distance a person has to travel to acquire alcohol. This will actually raise the risk of being
involved in a drunk driving accident. They claim that dry counties have 2.145 fewer fatal alcohol-related motor vehicle accidents than wet counties per year [12]. This does not seem like a very significant economic effect. It is widely known that complete prohibition of alcohol has not worked in the past, and this may be the reason for such low numbers. My paper does not concentrate on the two extremes, wet and dry, but rather look at the effect that a higher tax has on consumption and drunk driving.

Phillip Cook has also investigated the effects of alcohol taxation on drunk driving consumption and accidents. In this 1981 paper, he concluded that higher taxes on beer significantly reduce traffic mortality rates [13]. In cooperation with Grossman, he concludes that it’s a matter of “how much” tax rather than “whether”. In my paper I will try to substitute different tax amounts to see if there is a threshold for a significant change in the variables.

3. BACKGROUND

3.1 Structure

The American government has tried numerous ways to curb alcohol consumption in order to reduce crime and corruption, solve social problems and improve health and hygiene in the country. One of these extremes was the Prohibition of 1920. It was backed by the 18th Amendment and the Volstead Act. These acts outlawed manufacturing, sale and transportation of intoxicating liquors, which are defined as “beer, wine, or other intoxicating malt or vinous liquor with more than 0.5% alcohol by volume” [14].

Before the prohibition, beer accounted for more than half of the total alcohol consumption, and during the prohibition the beer consumption fell by 70% [15]. This would imply that prohibition must have had a significant economic effect on the society, but the back story of prohibition is that per capita consumption of wine increased by 65 percent and
spirits (vodka, whiskey, etc.) by 10 percent [15]. The reason for this is illegal manufacturing and distribution of alcohol, which increased during the prohibition period. Beer was less profitable and more costly to distribute due to high production and storage costs and because liquor was valued by alcohol content, beer was less profitable to produce. In addition, the number of problems skyrocketed during this period. The reason was that homemade liquor was more dangerous to consume since many individuals disregarded health codes when they produced the alcohol. The illegal production of liquor increased and its consumption became harder to monitor. In the long run, the prohibition did not achieve its intended purpose of curbing alcohol consumption.

A major problem arising from alcohol consumption is driving under the influence. In the 1980’s, nearly 60% of all fatal crashes were caused by alcohol. To deal with this epidemic, the government responded with legislation. The very first laws were very generic, simply prohibiting driving while intoxicated. This was not very effective because the law did not specify any limits. To combat this, the government started passing quantity specific legislation. They concentrated on the alcohol blood level which could be defined by a breathalyzer test given when a person is pulled over. The government specified level counts as a threshold point for criminal offenses. The first generally accepted legal limit for blood alcohol concentration was .15 in 1910. Even though the number of drunk driving accidents decreased, it was still a significant problem in the society. The government responded by enforcing administrative laws which acted as stricter rules for violations on top of drunk driving. For example, accidents where the drunk driver caused an accident requiring the hospitalization of another person lasting greater than a specified period of time, where an
accident resulted in property damages exceeding a certain amount, or where the driver had prior convictions for drunk driving could be subject to suspension of driving privileges [16].

A more active approach to drunk driving was taken in the 1970’s when groups such as MADD (mothers against drunk driving) and SADD (students against drunk driving) emerged to fight this epidemic and is high mortality rates. Since their beginning, they have influenced a lot of legislation such as reducing the legal blood alcohol level to .10, which has been further reduced to .08, the current national level. The consequence for breaking this law is immediate license suspension. These laws have definitely curbed the number of accidents involving alcohol.

Probably the most significant effect on consumption and drunk driving has been the enactment of the minimum 21 age requirement. This law states that persons 21 and under, minors, cannot legally buy, consume or have possession of alcoholic beverages. Even though the government has not required the states to adopt this law “per se”, they made sure to make the states accept this law “voluntarily”. Since highways are considered government property, the government is responsible for giving out funding for highway building and maintenance to each state. If a state does not adopt the 21 and over law, the government will refuse highway and roadways funding to that state. Since the 21 law went into effect, alcohol consumption has declined along with traffic crashes, but the first alcohol use is slightly up, which is the level of alcohol consumption immediately following a person’s 21st birthday. This is the good/bad part of this policy. It successfully reduces alcohol consumption by targeting younger individuals and reducing their risk of becoming alcohol dependent. This in fact has a long lasting effect as these individuals age and do not engage in excessive drinking activities or develop addictive behaviors towards alcohol. A person’s brain is still developing
at the age of 18, and does not finish developing much before age 21, possibly making youth more susceptible to addiction [17]. It also causes a significant decrease in drunk driving. Underage people are known to be dangerous drivers due to lack of experience. People ages 16-24 were involved in 28% of all alcohol related accidents, although they make up only 14% of the U.S. population [18]. Not letting these individuals consume alcohol lets them gain experience and keeps the roadways safer. But by creating a barrier effect, it is easy to see why there could be a jump in first time alcohol usage and binge drinking. As these persons turn 21, they will be more inclined to try alcohol as they have not been legally allowed to do so; this is reflected in the alcohol abuse and high binge drinking numbers. Since most people turn 21 in their college years, these effects can be seen on college campuses and their statistics. Binge drinking in this paper is defined by consuming 5 or more drinks in 30 minutes or less. As mentioned before, it is challenging to collect data for underage consumption and binge drinking because alcohol sales to minors are illegal. Due to this and the lack of data in this area, we will not focus on underage consumption in this paper. Though it is widely accepted that a higher drinking age significantly reduces the consumption and drunk driving variables.

Ideally, taxes should be able to achieve the same results as some of these policies, especially dealing with minors. Taxes can be passed on to the consumers because of inelastic demand for alcohol; this is widely caused by little amount of legal substitutes for alcohol. This in effect raises the prices charged to the consumer and makes the product more expensive. Grossman studied that younger individuals’ demand is more elastic due to their budget constraints and in theory a higher price should curb minors’ consumption. For individuals over 21, taxes could also act as a limit on how many drinks they can afford. This could have a tremendous effect on alcohol related accidents and injuries.
3.2 History of Taxation

There are two major parts that comprise the beer tax, federal and state level. Before 1951, the tax for beer was $8 per barrel, which amounts to roughly $0.26 per gallon, considering there are 31 gallons in a barrel. Put in real terms, you would pay $0.26 for every 10 glass bottles of beer that you bought, which seems like a minute amount even in that period. In 1951, the beer federal tax increased to $9, which amounted to a $0.04 increase in tax per gallon [19]. This increase in tax makes the government appear reluctant to charge significantly higher prices on alcohol; understandably, they have a good reason to do so. Tax comprises a major part of the government income, and tax on such an item as alcohol, an item that is imbedded in the American culture, is a guaranteed source of income. In 1996, the Department of Treasury collected $3.335 billion from beer sales alone [19]. The government does not want to increase prices so high that buyers are turned away from this product to other options, such as illegal drugs from which the government would get nothing. All this changed with the emergence of groups such as MADD, which as stated earlier, played a big role in pressuring the government to pass more legislation and enforce stricter penalties for drunk driving. In 1991, the federal tax rate was doubled to $18 per barrel. This translates into $0.58 per gallon. You can say this is a significant increase in the tax rate, but you would be missing one major detail. Because this tax is a flat rate, inflation can be harmful in sustaining tax’s value over time. Inflation occurs when the price increases over time for the same basket of goods. For example, an apple that cost $1 in 1990 may now cost $6. Since it takes more and more currency to buy the same product, inflation actually devalues money. Figure 1 shows inflation by decades since 1913 [20].
Because of inflation, the early tax of $9/barrel dwindled to almost nothing in the 1990’s. Doubling the tax rate did fix the rate for inflation, but the problem with the government not regulating this on a regular basis is that tax eventually disappears. Adjusting the tax every 40 years is not sufficient. It might play a tremendous role at the time the law is passed, but 18 years after the tax increase, a 60 cent tax on every 10 glass bottles of beer does not seem to be significant enough to stop anyone from buying alcohol or even giving this purchase a second thought. But if beer tax was adjusted for inflation on a more regular basis, it would be more than 3 times today’s $18 per barrel rate [22]. The problem of inflation could also be solved with a tax that is a percentage of the price.
The second part of the beer tax is implemented on the state level. Each state charges its own flat rate on a “per gallon” basis. In 2004, the average rate for all the states equaled $0.26 per gallon, with 32 states falling below that and 18 states above [21].

As you can see from the graph, the taxes range from $0.02 in Wyoming to $1.07 in Alaska. This range is mostly due to the fact that there is no specified time period when states have to renew the beer tax. In 2004, more than 20 states had not raised their beer tax in the past 20 years. As with the federal tax, inflation has taken its toll on states that have kept their tax constant over time by reducing the value of the tax close to zero. Table 1 shows these effect on the current lowest beer tax states [21].

This constant erosion in value could be contributing to an increase in consumption, which might not be so easily detectable in the data. Because alcohol becomes cheaper, relative to other items, more individuals are able and willing to consume it. Rather than follow the year to year change in tax and consumption due to inflation, we consider the tax
constant over time until it is renewed. This paper primarily focuses on the process of renewing the tax. Disregarding inflation, we can see if raising the tax rate has any significant changes in our variables of alcohol consumption, drunk driving and binge drinking.

3.3 Taxation Record Keeping

The biggest challenge of this paper has been data collection. This is primarily due to recent developments in technology and the widespread use of the internet. Due to time constraints, all the data for this project was collected from public available information via the internet. The web did not come into widespread use until the late 90’s, which means not much data is available before this period. The majority of the unavailable data, if it even was collected, was done in a paper-and-pencil method, but it is very costly and time consuming to convert these databases into electronic form. Therefore, we will concentrate mainly on the period 1982-2004, for which we were able to find information for all the states.

<table>
<thead>
<tr>
<th>State</th>
<th>Current beer-tax rate (per gallon)</th>
<th>Deflated beer-tax rate (per gallon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyoming</td>
<td>$0.02</td>
<td>$0.01</td>
</tr>
<tr>
<td>Missouri</td>
<td>$0.06</td>
<td>$0.01</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>$0.06</td>
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<tr>
<td>Colorado</td>
<td>$0.08</td>
<td>$0.02</td>
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<tr>
<td>Oregon</td>
<td>$0.08</td>
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<tr>
<td>Kentucky</td>
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<td>Pennsylvania</td>
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<tr>
<td>Maryland</td>
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<tr>
<td>DC</td>
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<tr>
<td>Rhode Island</td>
<td>$0.10</td>
<td>$0.07</td>
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</tbody>
</table>
4. THEORETICAL DISCUSSION

In this section we will discuss the theory behind the empirical analysis that follows this section. We will also discuss the data and how each piece of it is measured. This section will describe the roadmap taken to complete the analysis and determine the possible outcome by developing several specific equations. These equations will encompass the variables collected in our data and demonstrate how they are relevant in each specific outcome.

4.1 The Data

The data for this paper was collected from different credible sources on the internet, such as U.S. Census Bureau (http://www.census.gov/), which collects data on the national level every 10 years and also makes yearly estimates in wide range of areas. The data is organized by state and does not include Puerto Rico or the D.C. area. The time period range is 1982-2004 and is done on a yearly basis. The reason for this period is the availability of the majority of the data in all variables. The data is set up to represent panel data, which is used to look at any changes in same observations over a time period. For example, observations A and B have time periods 1, 2 and 3. Panel data looks at the changes in A1 A2 A3 and B1 B2 B3. In our case, the panel data tries to determine effects of specific variables such as price or population over the years in a state. All the states are also divided into regions: Midwest, South, West and Northeast; this classification will help determine if there are significant differences in consumption, binge drinking or drunk driving across the regions. The Midwest and South regions are known for high levels of drinking and could potentially have a significant effect on the data; for this reason, we included regional groups in our database.

The consumption level is beer specific data measured in per state per year in “per capita ethanol consumption in gallons”. In our analysis, we will first briefly look at the federal
tax that was passed in 1991 and if it had any effect on the national consumption level. We will then look at the state levels and how those are affected. Figure 3 shows the average consumption of all the states for years 1984-2004, we will look if the slopes are significantly different for the pre 1991 and post 1991 periods. Our hypothesis is that consumption decreased after year 1991. Holding all other variables fixed, this change would imply that tax was the determining factor.

Unlike consumption, measuring drunk driving is a little trickier, since some of the drunk drivers get away with it or are not turned in by the police. For our data, I decided to use fatal crashes; accidents that involve alcohol are considered drunk driving accidents. Dividing the drunk driving accidents number over the total accidents number gives us a percentage of drunk driving for that specific state in a specific year. The only setback of these numbers is that they are not beer-specific; ethanol is the same across all alcoholic beverages and it is impossible to determine what specific type of alcohol (beer, wine or hard liquor) it came from.
and the specific amounts consumed. But because beer makes up such a big percentage of total alcoholic beverages consumed, any changes in this alcohol type should show up in the analysis. These numbers are provided by Alcohol Alert (http://www.alcoholalert.com/index.html), which houses many drunk driving statistics and is one of the many sites working to reduce these fatalities. Similar to consumption, we will first look at possible effects of a federal law on this data. Figure 4 shows the average drunk driving levels (in percents) across all states for period 1984-2004. We will then look at state specific data; our hypothesis is that a higher tax would produce a lower % of drunk driving.

Another variable that we will look at in our analysis is binge drinking. As stated earlier, binge drinking involves 5 or more drinks in 30 minutes or less. Our data shows how much of a specific state has reported binge drinking in the past year. There are a couple
setbacks with this data. First of all, it is not beer specific since binge drinking involves any alcoholic beverage. As with the drunk driving statistic, this makes it impossible to figure out how much of a specific alcohol type was consumed. This data is also collected with surveys and questioners, which unlike alcohol sales or fatal car accidents, is very subjective to responses. People’s willingness to reveal such information about them could skew the data in either direction. As with the other two variables, we will look at the effects of federal tax, yet the averages do not seem to show any changes in the post 1991 period. Figure 5 shows the averages of all states for the periods 1984-2004.

Other variables included in the database are personal income and population estimates. These are pretty self explanatory as to why they would be included in this analysis. Personal income will show if there is any effect on our dependent variables depending on how rich the state is or how many people live in that state. To better understand the population and its effect on alcohol use, we needed to determine the age distribution. This is easily seen with Florida; it is a heavily populated state with 14,683,350 population in 1997, but the age group 20-24 makes up only 8% of that number, whereas people over 65 make up 18%. In order to account for a possible estimates error, we have included age breakdowns: under 18, 20-24, 25-44, 45-64 and over 65.

The last piece of the data is the state excise tax. Because we’re looking at such a short period of time (only 18 years), there is little change in the taxes, as discussed later, this could constitute a problem in our analysis. We consider tax to represent the price on beer, since a tax increase will be passed to the consumer in a form of a higher price.
4.2 The Theory behind the Empirical Analysis

The model employed in this paper consists of three major equations. The first one deals with consumption and the variables that might have an effect on it. The variables included in this equation are the variables for which we have data, but there are a number of other variables that could potentially have influence on the level of consumption; these variables are considered in variable “u”. By possibly omitting a very important information variable from the regression, there is a potential that our estimates are biases; we are confident that we have included the major variables in our regressions. They may include weather (rainy or snowy weather may encourage more drinking), whether it is an urban or rural area, or if the area is a college town (which seems to show significantly more alcohol consumption and binge drinking). Looking at our equation, age should have a negative effect on consumption: people in their 60’s will probably drink less than people in their 20’s. Age is divided into 5 sub-categories to avoid error in the estimates. For example, people under 18 will probably not have high consumption levels because it’s illegal, yet people in 20’s will and the levels for people in 60’s will also be lower. Income should have a positive effect, the more people earn the more they are willing to spend on alcohol. Price, which acts as the tax here because the tax would be passed on to the consumers in the form of higher prices on a product, will most likely cause \( \beta_3 \) to have a negative effect on consumption. Population is uncertain as it can probably play an effect both ways: more people in the area means more social drinking whereas less people in an area might mean a rural setting, which might be low on the entertainment aspect.

\[
\text{Consumption}_{it} = \beta_0 + \beta_1 \text{age}_{it} + \beta_2 \text{income}_{it} + \beta_3 \text{price}_{it} + \beta_4 \text{region}_{it} + \beta_5 \text{population}_{it} + u
\]
The second equation has to deal with drunk driving and how it is affected. Drunk driving is directly influenced by how much alcohol was consumed, which implied that all the variables affecting consumption in equation 1 also influence equation 2. In our empirical analysis, we will use the actual consumption levels observed, not the estimates from equation 1. Once again, there are many other variables that have an effect on drunk driving, they’re included in $e$. Drunk Driving and Binge Drinking are measured in percents, whereas all the other variables are in regular numbers.

The third major equation for our analysis is dealing with binge drinking. Drunk driving does not play a major role in affecting binge drinking so it not included in the equation. Probably the most relevant factors for binge drinking would be age and college town. It is a known statistic, that binge drinking is a serious problem on college campuses across the nation, affecting the 20-24 age group significantly.

From equation 1 we can also establish elasticity of demand which will show us how sensitive individuals are to price changes in beer. Then we can establish a connection between the elasticity of demand and drunk driving.
4.3 Discussion of the Analysis Methods Used

For this paper, we will utilize two econometric methods for panel data: fixed effects and differencing. Running the database as cross-sectional data would be inefficient and it would give us misleading results. Cross sectional data is a one-dimensional data which observes many subjects at the same point in time, without any regard to differences in time. Unlike cross-sectional data, panel data follows the same units over a period of time. We will discuss each method more closely. After these two models, we will try to implement the two-stage least-squares method on our data. To follow-up, we will try to justify using this method and do a side by side comparison of the results.

Mostly all of the regressions will include an unobserved factor, usually imbedded in the error term. These include characteristics which are hard to quantify or observe, such as level of ability or intelligence. The method of fixed effects divides these unobserved factors into two distinct parts: the fixed effect and the idiosyncratic error, which is time-varying.

The above equation shows what a typical fixed effect regression would look like, though in our case, our time variable (t) would include 22 instances, accounting for each year in our range. The variable $d2$ is a dummy variable that equals zero when $t=1$ and one when $t=2$, in our case, we would have 21 of these; this concept will allow the intercept to change for each state. The $a_i$ variable is called the fixed effect and it captures all unobserved time-constant factors that affect $y_{it}$. These factors can include many different things. The geographical location of a state does not change over time, but it might make it significantly different from
other states. For example, Wisconsin is known to be cold during the winter months, which might lead its population to drink more, whereas Texas always has comfortable temperatures and this could encourage people to stay active and drink less. Demographics, which might not be exactly but roughly constant over a time, can play a big role also. For instance, many retired individuals move to Florida due to its warm climate and atmosphere, which makes its demographic distributions very different that those of California or New York. Going back to the equation, the error term, $u_{it}$, is called the idiosyncratic error that represents unobserved factors which change over time and affect $y_{it}$. So in the end, the fixed effect model creates a fixed effect variable for each state. It then evaluates the average of these fixed effects to determine the yearly mean for all the states. The next step for this model is to take each state’s specific regression and subtract it from the mean equation, which would determine how that state compares to the rest of the country in that specific year. For example, this would probably determine that Florida’s population of people over the age of 65 is significantly different than the mean for the whole country. The fixed effect model will help us estimate alcohol consumption, drunk driving and binge drinking by taking out state specific effects. This in fact, will make our data more reliable and increase its importance because it now can be applied to all states.

The other method we will apply to this data is differencing. Similar to fixed effects, differencing also tries to eliminate a time-constant unobserved effect. We start out with the fixed effects model:

$$y_{it} = Q_1 + Q_2 d_2 + B_1 x_{it} + ... + B_k x_{itk} + a_i + u_{it}$$

Eq. 5
Similar to the previous equation, we include an intercept for each year. The $a_i$ still represents the unobserved effect that does not change over time and $u_{it}$ represents one that does. The key assumption is that idiosyncratic errors are uncorrelated with the explanatory variable in each time period; that is, the explanatory variables are strictly exogenous after we take out the unobserved effect, $a_i$. If $a_i$ is correlated in any way with $x_{it}$, then $x_{it}$ will be correlated with the composite error. This method then works to eliminate $a_i$ by differencing adjacent periods.

$$
\begin{align*}
  y_{it} &= Q_1 + Q_2 d_{2t} + B_1 x_{it1} + \ldots + B_k x_{itk} + a_i + u_{it} \\
  \Delta y_{it} &= Q_2 \Delta d_{2t} + B_1 \Delta x_{it1} + \ldots + B_k \Delta x_{itk} + \Delta u_{it} \\
  y_{it} - y_{it-1} &= x_{it}B - X_{it-1}B + a_i - a_{i-1} + u_{it} - u_{it-1} \\
  a_{i-1} &= a_i
\end{align*}
$$

In order for the standard errors and test statistics to be valid, we must assume that $\Delta u_{it}$ is uncorrelated over time. In the long run, the first-differencing model, just like fixed effects model, gets rid of any variables that are constant over time, but it does use a different method.

Even though these two methods seem to be very qualified for this type of regression, we could be concerned that one of our explanatory variables is correlated with the error term. That is, in our drunk driving regression, there is something else not accounted for, something in the error term, that could be correlated with a variable such as consumption. This unaccounted variable could cause biased and inconsistent estimates. To solve this problem, we could use an instrumental variable to run the two stage least squares model.

To explain this concept more clearly, refer to equation 7. Suppose our equation for drunk driving consists of all these explanatory variables and we believe that except for consumption, all other variables are uncorrelated with drunk driving. We also think that peer
Drunk Driving\(_{it}\) = \(\delta_0 + \delta_1 \times \text{age}_{it} + \delta_3 \times \text{price}_{it} + \delta_4 \times \text{region}_{it} + \delta_5 \times \text{population}_{it} + \delta_6 \times \text{consumption}_{it} + \delta_7 \times \text{time}_{it} + \delta_8 \times \text{binge drinking}_{it} + \delta_9 \times \text{total accidents}_{it} + \delta_{10} \times \text{bar last call}_{it} + s\)

Consumption\(_{it}\) = \(\psi_0 + \psi_1 \times \text{peer pressure}_{it} + \psi_2 \times \text{city}_{it} + \psi_3 \times \text{weather}_{it} + \delta_1 \times \text{age}_{it} + \delta_3 \times \text{price}_{it} + \delta_4 \times \text{region}_{it} + \delta_6 \times \text{consumption}_{it} + \delta_7 \times \text{time}_{it} + \delta_8 \times \text{binge drinking}_{it} + \delta_9 \times \text{total accidents}_{it} + \delta_{10} \times \text{bar last call}_{it} + p\)

Looking back at the above example, there could be number of things in the error term, \(s\), that are correlated with consumption and could be skewing the data. One of these possibilities, although hard to quantify, is peer pressure. Many people will drink if they are in a group; either because they feel more comfortable drinking or they get pressured into it by their friends. Either way, peer pressure most likely plays a role in consumption; the only problem is that we do not have this sort of data in our database. Another idea is that income could possibly be having the same effect on this regression. The higher a person’s income is, the more alcohol that person will probably consume; but just because a person makes more money does not mean they will drive drunk more often. We will use income as an instrumental variable in our empirical analysis of 2sls (two stage least squares). We must address one main issue with this example right away. We must assume, as will be discussed next, that drunk driving and income are not correlated. This type of assumption greatly contradicts the already established fact that younger individuals are most affected by price changed because of their limited income. This implies that there is definitely some sort of relationship between drunk driving and income. This fact could make our 2sls not valid.
In order to run 2sls we need to make two big assumptions. The first one is that the instrument MUST be correlated with the explanatory variable. In our example, income and consumption should show a pretty high correlation. The second assumption is that the instrument cannot be correlated with the error term in the explanatory equation. In other words, the instrument cannot suffer from the same problem as the original predicting variable. In our example, this could be expressed by correlating income and drunk driving, which should provide no or very little correlation.

4.4 Potential Problems

There are a couple of potential problems that could occur while running analysis on our database. The data only looks at 22 years of observations, which could be not enough to find significant results. This problem is intensified in the field of taxation. Taxes stick around for a number of years and when they are changed, the change itself is not big. Because of this, there is not much variation in the tax variable, which makes it appear as if it was a variable not dependent on time, as in a fixed effect. The problem arises because our analyzing methods try to eliminate these effects. A way to eliminate this problem is to run the regressions as a pooled-cross-sectional data. This averages out all the variables over the years for each state and turns the database into a plain cross-sectional data. This method would eliminate the effect of time.

Another problem could be that we do not have enough variables to account for all the effects that could influence alcohol consumption, drunk driving and binge drinking; for example, weather can play a significant role on these variables. In states that are more rainy or snowy, the expected level of alcohol use and abuse is higher than in states where there is always sunny and warm weather. The reason for lack of these variables is their availability.
Some of this data just does not exist or is extremely time-consuming or impossible to get a hold of. The omitted variables problem can cause serious miscalculations and wrong interpretations in the analysis. The way to eliminate this problem is to continue to add relevant data to the database.

Even though omitted variables problem can occur, over controlling for some effects is another possibility. By including too many variables that deal with similar things into the regression, this can take away some of the effect of those variables. This could make a variable not appear significant when it really is. As with the previous problem, this can also cause misinterpretation of the analysis.

Although all of the data came from credible sources, it is still subject to measurement error. Some of the data is gathered by surveys, and a person’s mood that day or their want not to disclose such information can skew the data. Also, each state might implement different methods in recording the information, which can also influence the outcome of our regressions.

5. **EMPYRICAL ANALYSIS**

The data set employed here is a panel data study and consists of 50 U.S. states for the years 1982-2004. Applying the methods we discussed earlier, we want to analyze the data that we have collected.

5.1 **Federal Tax Empirical Analysis**

The federal tax was doubled in 1991 from 9$ to 18$ per barrel. Though this tax increase seemed significant, when accounting for inflation, this $9 increase was reduced to pretty much nothing. We wanted to estimate if an increase in the federal tax on alcohol actually caused a shift in people’s behavior towards alcohol use. Using a dummy variable to
distinguish between pre and post 1991, we can see that tax played a significant role in determining consumption in both periods and that after 1991, consumption actually fell. This could imply that the federal tax actually played a role in curbing the amount of alcohol consumed in the U.S. This effect can be seen more clearly in the drunk driving regression. The dummy variable shows a decrease of 9% from pre to post 1991. This is an economically and a statistically big effect on drunk driving. These findings definitely support our hypothesis that a higher tax leads to lower levels of alcohol abuse.

5.2 State Tax Empirical Analysis

The main point of this paper was to see if taxing beer would cause a significant shift in alcohol consumption, drunk driving and binge drinking. As a starting point, we ran a regression of consumption on all the age groups, annual population of the states, income, tax, and the region of the country where the state was located. The actual results can be found in the appendix. In a regular regression of consumption, a $1 tax increase would decrease the per capita consumption by .011 units. The age group 20-24 is also significant, except it contradicts a popular belief that this age group consumes the most alcohol. The relationship shows as there are more people in this group, the less they consume. Unfortunately, all of the significant numbers are so small, that these results would be hard to show that a relationship is really true.

In running fixed effects model on consumption, most of the variables become less significant, except for age group under 18, which suddenly does become significant, but its effect is close to zero. Tax is still significant, but its effect is now a (-.007) change in per capita consumption. Income remains strongly significant but a diminished and close to zero effect. The age group 20-24 changed its sign to reflect a positive relationship between itself
and consumption. When running the first-differencing method on consumption, all of the variables with no exception lose their significance. All of the age groups show a positive relationship towards consumption, whereas income and tax show a negative relationship.

As we mentioned earlier, the lack of significant and low effects could be due to not enough data or not enough variance in the data. The important thing is that tax and income stayed negative and somewhat significant in all three of the methods. Even though changing how much a person earns is probably impossible, it is possible to increase tax on beer, which clearly would lead to less alcohol consumption.

We ran the same models on drunk driving. In a regular regression of drunk driving on other variables, age groups 20-24 and under 18, along with tax were very significant. The relationship showed that more individuals in these groups lead to more drunk driving accidents. This finding validates the data by supporting the general consensus that these groups are considered dangerous drivers and due to this, their insurance rates are usually higher. Tax shows a negative relationship, stating that a $1 increase in tax would cause a .56% decrease in drunk driving rates.

When the fixed effects model was run on this data, age 20-24 lost its significance, but the under 18 group still contributed positively to the drunk driving accidents. Tax also became not as important but still showed that an increase in tax would lead to a decrease in drunk driving rates. Surprisingly, income remained extremely significant, but it did change the sign to a positive effect. In the first-differencing model, all of the variables lost their significance. Tax seemed extremely unimportant in effecting the drunk driving number, and it even changed to a positive relationship. These methods make an impression that income plays
a big role in how many drunk driving accidents occur, yet it seems absurd that the more income a person would mean he gets in not as many accidents.

Binge drinking seems to resemble the same kind of results as drunk driving. Under 18 and 20-24 age groups seem to be positively tied to binge drinking numbers. This is a known fact and actually a concern across many high schools and colleges campuses. Tax is also tremendously significant in this scenario and a $1 increase in tax would lead to a .25% decrease in binge drinking rates. Tax seems to have the biggest effect in the binge drinking case. This could be feasible when the tax, because it’s so high, significantly curbs the amount of drinks a person purchases, in the end reducing the number of people who could afford to binge drink.

With fixed effects, tax continues to be important in curbing binge drinking. But this method does skew some information; college level kids seem to have a negative effect on binge drinking. This type of relationship may make the data seem unreliable and could pose problems when involved in policy making. With first differencing, tax and the two age groups don’t seem to be as important in affecting binge drinking. This method doesn’t seem to show any variable having a significant impact on the amount of binge drinking, which makes the method questionable.

We now move on to the 2sls model, which we implemented only on the drunk driving part of the data. Once implemented, ageunder18, age2024, ageover65, annualpop, tax and midwest were statistically significant variables. This regression predicts that a 1 unit increase in tax will decrease drunk driving by .546%. The interesting thing about this estimate is that it’s not very different from the tax estimate of running a regular panel data regression on
drunk driving, which is a .548 decrease. The coefficient of consumption on the other hand increases by 3 units when run as a 2sls, though it’s not as significant.

In the end, it seems that 2sls seems to point to the fact that consumption does influence drunk driving, which is the same results we got from the other two models. Consumption, as we determined is affected by tax, so there seems to be some connection between tax and drunk driving in the 2sls model.

There does not seem to be much difference between OLS and 2SLS models. A side by side comparison of the estimates is presented below.

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5.3 Error Analysis

The above analyses seem to show some significant relationships between the variables. Yet when the different methods were run in all 3 cases, the majority of the variables lose their significance and impact. One of these reasons, discussed earlier in the paper is that there was not enough data to capture the real effect of the variables. This could cause major misinterpretations of the data and create misleading relationships, such as college level kids having a negative effect on binge drinking. Tax, which seems to show an overall effect on alcohol consumption, doesn’t seem to show a strong significance in alcohol use and abuse. Though tax probably does play an important role in this subject, the long term effect of tax and its lack of variance in our database could cause this relationship to be miscalculated.

When performing 2sls, we needed to make two major assumptions:

- The instrument must be correlated with the explanatory variable
- The instrument cannot be correlated with the error term in the explanatory equation

To validate the first one, we found the correlation between consumption and income, which should have turned out pretty high; in reality, it was only -.2160. This is not a very strong relationship and could pose a problem.

We then tried to validate the second assumption by finding the correlation between drunk driving and income, which should have turned out small, if not at all nonexistent. The real correlation turned out to be -.2280, which by far is nowhere close to zero. Both of the correlations are about the same strength and therefore could imply that there is a problem with our instrument. Since we do not have any other instruments to use from our database, we will stick with income, but otherwise, it doesn’t seem that our 2sls method is very valid or useful.
6. CONCLUSION

It is widely known fact that alcohol is a major consumption among Americans. Unfortunately, many Americans seem to misuse this substance. This causes many side effects, long and short term, from headaches to liver failure to overdosing. Alcohol over-consumption can lead to irresponsible behaviors such as driving under the influence. This not only causes a potential health problem for the driver, but also a social problem for all the other drivers on the road. Aside from drunk driving, many individuals consume too much alcohol in one sitting. Binge drinking has been a serious problem for people under 25, mostly on college campuses across the nation. This paper looked at the different aspects that could be affecting alcohol consumption and tried to establish a relationship between the price of beer and its use. The assumption was that a higher tax on beer, therefore producing a higher price, would reduce alcohol consumption and binge drinking. This should also decrease drunk driving, but not through tax directly, rather indirectly though consumption.

We treated our data as panel data and ran fixed effects and differencing on the database. The end conclusion was not a 100% convincing, yet it did establish the evidence that a higher tax does lead to a lower consumption, drunk driving and binge drinking. This data can be useful in passing legislature to enforce stricter rules regarding driving under the influence. This type of legislature could save hundreds of lives across the nation every year.
7. REFERENCES


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