ASSOCIATION BETWEEN ALCOHOL TAXES AND HEALTH HARMS

A UK FRAMEWORK

by

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ABSTRACT

Background: Alcohol use is prevalent in the United States and is related to preventable injuries, deaths and health care and other costs. With the use of the Sheffield Alcohol Policy Model, this study concentrates on the policy intervention of the taxation of alcohol and how it can reduce health harms attributable to alcohol.

Methods: A major acute health harm attributable to alcohol is road traffic accidents. With the use of the Fatality Analysis Reporting System (FARS) database, I analyzed monthly data on injuries and fatalities from drinking-related accidents. I looked at the State of Connecticut for its policy implementation of a 20 percent increase on the per-gallon excise tax on all types of alcohol in July 2011. The analysis used the autoregressive integrated moving average model to examine 2000 to 2016 FARS data for any association among the higher tax and health harms by drinking-relating accidents. In addition, a model on underage drivers was run to examine any possible difference in the effect of the tax increase by age.

Results: The tax increase was associated with 1.8 fewer injuries and fatalities per month by alcohol-related crashes, a reduction of 15.7 percent. For alcohol-related crashes of underage drivers, the tax increase was associated with a larger monthly decline of 44.4 percent. The results were found after using controls.

Conclusion: Intervention of alcohol taxation has the potential to reduce the harms related to alcohol use. Public policy should consider the different forms of taxation and consult evidence-based taxation scenarios, such as this study and the Sheffield Alcohol Policy Model, when forming policy.

Chapter 1

INTRODUCTION

The use of alcohol is widespread in the United States and has been attributed to harmful drinking behaviors, injuries, fatalities and high financial costs. The 2015 National Survey on Drug Use and Health found and reports the prevalence of alcohol use in the U.S. The 2015 survey found that 51.7 percent of respondents had reported drinking alcohol in the past month, 24.9 percent reported binge drinking in the past month, and 6.5 percent reported heavy alcohol use in the past month. Binge drinking is defined as drinking five or more drinks in one sitting for males and four of more for females; heavy drinking is defined as binge drinking five of more days in a 30-day period (Substance Abuse and Mental Health Services Administration [SAMHSA], 2015). The prevalence of binge drinking is more than one-third of respondents in the 18-25, 26-29 and 30-24 age categories. The most harmful drinking behavior of heavy alcohol use is most prevalent and just above 10 percent of respondents in the 18-25 and 26-29 age categories (SAMHSA, 2015). The behavior of alcohol use and particularly the abusive behaviors of binge and heavy use drinking creates a large societal problem in terms of public health. In young drinkers, the prevalence of these harmful behaviors is even more drastic.

According to the Centers for Disease Control and Prevention (CDC) more than 88,400 deaths are due to excessive alcohol use (Centers for Disease Control and Prevention [CDC], 2013). The CDC divides alcohol-attributable deaths across 54 acute and chronic conditions that are either wholly or partially-attributable to alcohol. For excessive alcohol use, the majority of fatalities are due to acute causes such as traffic

accidents, non-alcohol poisonings and suicide. Chronic causes of death include alcohol liver disease, liver cirrhosis and alcohol dependence syndrome (CDC, 2013). Annual alcohol-attributable deaths due to excessive alcohol use are also much higher in males than females (more than 62,400 compared to 25,900, respectively). The CDC data also show that 4,360 deaths-attributable to excessive alcohol use occur annually in the under-21 age group. More than 95 percent of those deaths in the under-21 group are due to acute causes, and majorly traffic accidents (CDC, 2013).

Excessive alcohol use and related harmful behaviors produce a large burden. Annually, excessive alcohol use was estimated to cost the United States $249 billion. The costs measured include health care costs, loss to productivity and other costs such as property damage or criminal justice costs (Sacks et al., 2015). In all, the prevalence of alcohol use and abuse is high in the U.S., which in consequence, leads to avoidable injuries, deaths and high costs. Some of these outcomes even affect those who do not choose to drink alcohol. A public policy intervention would be necessary to reduce these societal harms from alcohol consumption and abuse.

The Sheffield Alcohol Policy Model (SAPM), a theoretical and mathematical model developed in England, offers sound evidence for the role of alcohol taxation policies in reducing the consumption and harms related to alcohol. In large part, the SAPM addresses the policy of alcohol taxation and how it affects a large range of health conditions and costs. This thesis research begins with the problem of alcohol use and abuse and uses the intuition of the SAPM for public policy. My intention with this study is to identify the problem of alcohol use and how public policies of alcohol taxation can be used to limit the availability of alcohol in effort to decrease the societal consequences attributed to alcohol.

Chapter 2

LITERATURE REVIEW

2.1 The Sheffield Alcohol Policy Model: A Mathematical Model of Alcohol Taxation

To begin to assess the literature on policy to reduce the effects of alcohol, I will first review a policy model that was designed in England to test different policies of alcohol pricing. The Sheffield Alcohol Policy Model (SAPM) is a mathematical model that estimates how different policy interventions can affect alcohol consumption and eventually reduce the harmful societal outcomes attributable to alcohol. The history of the development of the SAPM shows the appeal of evidence-based quantitative analysis in supporting policy agendas to address a societal problem. The SAPM was initially developed into its first version in 2008 through an independent review funded and commissioned by the Department of Health in England. The original work was a collaboration of researchers at the University of Sheffield (England) and at the University of Victoria (British Columbia, Canada) (Booth et al., 2008b: 21). Their systematic review of the literature on harm by alcohol use and the effects of alcohol pricing and promotion was published in September 2008. The report reviewed the existing literature on the connections between the pricing and promotion of alcohol and the consumption and harm related to alcohol. The second part of the version 1 (also written as version 1.1) was the

mathematical model basing itself on literature and evidence gathered in the systematic review.

SAPM version 1.1 modeled three different types of policy mechanisms, including general price increases, minimum unit pricing and restrictions on alcohol discounting. General price increases are simpler methods of taxation in which the prices of all products of alcohol are raised by a certain percentage (Booth et al., 2008b: 6, 138). Minimum unit pricing puts a price floor to each unit of alcohol; therefore, no single unit of alcohol could be sold for under $0.60, for example. Instead of raising the price of all products of alcohol, the minimum unit price would only raise the price of the cheapest alcohol on the market (Booth et al., 2008b: 6, 138; Angus et al., 2014: 100). Restrictions on alcohol discounting would reduce or eliminate offers and discount alcohol prices that help to make alcohol more affordable in off-trade stores. For example, SAPM models policies that ban discounts of more than 30 percent (Booth et al., 2008b: 7, 138). The policy scenarios are all taken into consideration in the SAPM to limit the availability of alcohol to reduce sales, consumption and harmful outcomes.

Version 1.1 estimated the effects of the different policies using combined data from household and food expenditure surveys. In November 2009, version 1.1 was then extended under the direction of the National Institute for Health and Care Excellence (NICE) into version 2.0. Version 2.0 included four new components to expand the policy model including a mathematically updated look at pricing mechanisms including general pricing increases and the minimum unit price (Purshouse et al., 2009). In July 2013 the SAPM version 2.5 was published as a report to the UK government estimating a specific

government proposed minimum unit price of £0.45; the version also concentrated on the effects on consumers of different income levels and consumers over age 16, in addition to the groups identified in previous models (Meng et al., 2013). Version 3 is the latest version of the model which came out of a commission by Public Health England (PHE) in August 2014 to model alcohol policies based on cost-effectiveness (Angus et al., 2015). After having established the history of the development of the SAPM it is essential to discover the model's structure, inputs and outputs in order to use it as a backbone for my own research.

2.1.1 The Sheffield Alcohol Policy Model's Framework

In introducing the structure of the Sheffield Alcohol Policy Model (SAPM) I chose to focus on versions 1.1 and 2.0 from 2008 and 2009, respectively. The choice to describe versions 1.1 and 2.0 rather than a more recent version was for two reasons of practicality: although the theoretical models of version 2.5 and version 3.0 have been applied to other jurisdictions outside of England and the UK, such as Sweden and the Republic of Ireland, version 2 was applied to Ontario and British Columbia, Canada. As Canada represents a market outside of the European Union closer to that of the United States, I found it to be a more important reference. In addition, a lot of fundamentals of the SAPM were laid in the initial versions of the model; the literature of versions 1.1 and 2.0 adequately describe the model and its foundation to be used in following versions.

The conceptual framework of the SAPM is formed by two components: 1) the impact of a certain intervention on the alcohol consumption of the population

(abbreviated as the intervention to consumption function), and 2) the impact of the change, if any, in consumption on societal outcomes (abbreviated as the consumption to outcome function) (Purshouse et al., 2009: 19). The framework defines the theoretical basis that an alcohol pricing policy would first affect the consumption of alcohol, which in turn would have some effect on the harmful outcomes of the population's use of alcohol. Within component one (1) there are two steps in the mathematical computation, as described by SAPM: firstly, i) the impact of a certain policy intervention, such as a tax, on some factor of the availability of alcohol and, ii) the impact of the change in availability of alcohol on its consumption (Purshouse et al., 2009: 19). Component two (2) ties consumption through to what it considers "societal outcomes", which include three categories: a) health harms, b) crime harms, and c) workplace harms (Purshouse et al., 2009: 25).

Component one (1) of the SAPM, which refers to the intervention to consumption function, estimates alcohol consumption in England through the data inputs from two annual surveys and common measures to define alcohol use and abuse. The first of two surveys used is the annual cross-sectional General Household Survey (GHS), which asks UK households about their alcohol consumption over the past year. At the time of their analysis for version 2, they included data from 14,289 adult individuals across England, excluding the other countries of the UK, collected from the 2006 GHS (Purshouse et al., 2009: 21-22). From this data they were able to estimate average consumption and binge drinking behavior for the individual broken down by age and gender (Purshouse et al., 2009: 22). As the GHS only surveys adults, the SAPM makes use of the Smoking,

Drinking and Drug Use Survey (SDD). The SDD is administered annually in schools to students ages 11 to 15 in England. The SDD from 2007 was used with data from 7,831 students in order to estimate youth consumption of alcohol (Purshouse et al., 2009: 24). Neither of the surveys collect information on the price paid for alcohol but the SAPM makes use of the Expenditure and Food Survey (EFS) and research company data for information about prices (Brennan et al., 2015). The SAPM uses quantitative information derived from the surveys to compute consumption and how much people spend on alcohol. The information, combined with evidence on price elasticity was necessary for the SAPM to model the effects of the change of alcohol prices on consumption.

The common definitions that the SAPM uses to analyze alcohol usage are important to note and to compare side-by-side to definitions we use in the United States. The surveys on consumption that the SAPM uses (the GHS and the SSD) all measure quantity of alcohol in "units", which is a standard measure in the UK of alcohol. One UK unit equals 10ml (approximately 0.34 US ounces) of pure ethanol (Purshouse et al., 2009: 20). In the U.S. alcohol advice says that a "standard drink" is equivalent to 0.6 US ounces of pure alcohol (U.S. Department of Agriculture [USDA], 2015: 102) in comparison, the U.S.'s measurement is larger than the UK's. Another definition used by the SAPM is the classification of drinkers into three categories based on their consumption. In the UK, moderate drinkers consume no more than 21 units (210ml ≈ 7.10 US oz) a week for men, and 14 (140ml ≈ 4.73 US oz) for women; hazardous drinkers consume more than 21 but less than 50 units (500ml ≈ 16.91 US oz) a week for men, and more than 14 but less than 35 units (350ml ≈ 11.83 US oz) a week for women; harmful drinkers consume above 50

units a week for men, and above 35 units a week for women (Purshouse et al., 2009: 21).

Within these categories and quantities, they define binge drinking as consuming above

the units for the week in any single sitting. To compare measures of drinking between the

UK and the U.S., the USDA offers the American definition of moderate drinking. In the

U.S., drinking in moderation means men consume no more than 2 drinks a day, and 1 for

women (USDA, 2015: 15). A moderate male drinker in the UK can consume up to 3 units

of alcohol a day (21 units over 7 days), or approximately 1.01 US oz a day, whereas in

the U.S. a moderate male drinker can consume up to 2 drinks per day, or 1.2 oz a day of

alcohol. The maximum intake for a moderate female drinker in the UK is approximately

0.68 US oz a day, whereas in the U.S. it is at 0.6 oz a day. The moderate intake for a male

is slightly larger in the U.S. than in the UK (1.2 oz versus approximately 1.01 oz a day of

alcohol in the UK) but for females is larger in the UK (0.6 oz versus approximately 0.68

US oz a day in the UK).

Once the model estimates consumption and any changes caused by policy, the

SAPM proceeds to component two (2), which relates the change in consumption to

alcohol-related outcomes. The model uses an epidemiological framework to connect

consumption changes to harm. The harms that the SAPM considers include health harms

resulting in morbidity and mortality, crime and workplace harms. The component is

computed through risk functions that are derived from literature and evidence that are

incorporated into the SAPM (Purshouse et al., 2009: 25). The 47 health harms that are

attributable to alcohol use were taken from a North West Public Health Observatory

(NWPHO) report (Jones et al., 2008). That same report also provided SAPM with a

statistic for each type of harm that attributed it to alcohol, known as alcohol-attributable fractions (AAF's). AAF's are calculated by using quantitative evidence on the causal relationship between alcohol consumption and some health harm (Jones et al., 2008); the statistic was necessary for SAPM to model how each of the health outcomes changes as consumption changes. The NWPHO classifies health harms into four different categories based on their attribution to alcohol consumption, categories which the SAPM also uses: 1) Wholly attributable chronic conditions, such as alcoholic liver disease for which chronic alcohol consumption is the only cause; 2) Wholly attributable acute conditions, such as alcohol (ethanol or methanol) poisoning for which acute alcohol consumption is the only cause; 3) Partially attributable chronic conditions, such as malignant neoplasms for which chronic alcohol consumption may not be the cause of the condition but alcohol consumption changes its risk; and 4) Partially attributable acute conditions, such as road traffic accidents for which acute alcohol consumption may not be the cause of the condition but alcohol consumption changes the risk (Jones et al., 2008; Purshouse et al., 2009: 31). The wholly attributable categories of one (1) and two (2) have AAF's of 100 percent because without alcohol consumption the conditions cannot occur; for partially attributable conditions categories of three (3) and four (4) the AAF's are less than 100 percent and are ultimately found by SAPM in other literature (Purshouse et al., 2009: 31-32). The SAPM then includes a time component, estimating how the risk for health conditions change over time. Apart from health harms, the SAPM includes outcomes of crime and workplace harms. To estimate outcomes of non-health harms, the SAPM used risk functions for 20 different classifications of crime. Workplace harms, including

absence from work, unemployment and lost output due to death (Purshouse et al., 2009: 38), were also included using similar risk functions found in the literature and derived from labor surveys (Brennan et al., 2015).

The version 2.0 report that was given to the National Institute for Health and Care Excellence (NICE) concluded with results from a series of 33 policy options and interventions. In the report the SAPM was used to evaluate the effects of three different types of interventions: general price increases (9 policies), minimum price policies (17 policies) and off-trade discounting restrictions (7 policies) (Purshouse et al., 2009: 101). The SAPM's findings help to show the potential of different pricing policies of alcohol. Outcomes shown for each policy scenario include: 1) reduction in alcohol consumption by age, gender, category of drinker and type of drink; 2) change in consumer spending by age, gender and category of drinker; 3) change in sales and tax/duty; 4) change in health outcomes, such as hospitalizations and deaths attributable to alcohol; 5) change in crime attributable to alcohol; 6) change in work-related harms, such as absenteeism and unemployment; and 7) change in costs and other financial expenditure attributable to alcohol, such as in the National Health Service (NHS) health costs and in crime (Purshouse et al., 2009: 109-134).

The report highlighted in particular the expected outcomes of a £0.40 (or 40 pence [p]) minimum policy. The model found that a policy of a 40p minimum unit price would result in: lower overall weekly consumption of alcohol (-2.4 percent), with the greatest drop in harmful drinkers; fewer deaths within the first year of implementation (198 deaths); lower hospital admissions (8,000 fewer people in year 1) and lower health care

costs (£33.4 million in year 1); fewer instances of crime (10,100 instances per year) and lower cost of crime (£11.7 million in year 1); fewer people unemployed (11,500 people) and fewer sick days taken (134,000 days) per year, to name a few (Purshouse et al., 2009: 109-112).

The other non-minimum unit pricing policies tested by this version 2 of the SAPM resulted in varying effects to alcohol consumption and harms. In terms of consumption, they found that general pricing increases create large reductions in the population's consumption, and that greater pricing increases have stronger effects. Minimum pricing techniques reduce consumption and higher minimum prices have drastic effects on consumption (Purshouse et al., 2009: 109-112). Similarly, restrictions on off-trade discounts have a reductive effect on consumption. As would be expected, all of the reductions in consumption have effects in component two (2) of the model; that is, they reduce health harm, crime, work harm and the costs associated (Purshouse et al., 2009: 109-112). The SAPM's clear results of different policy options to reduce alcohol consumption and related harm distinguish it as a tool for crafting policy. The model's findings create a strong basis for the consideration of alcohol tax policies, in particular the minimum unit price, by governments interested in decreasing the harmful effects of alcohol.

2.1.2 The Sheffield Alcohol Policy Model: Research and Public Policy

The Sheffield Alcohol Policy Model (SAPM) was started by a commission of the English government to investigate how targeted policies of alcohol pricing could reduce the harmful effects of alcohol. Not just in England, however, are the harmful effects of alcohol use regarded as a public health threat. In 2012, as reported by the World Health Organization (WHO), 5.9 percent of global deaths or about 3.3 million deaths, were estimated to have been caused by alcohol (World Health Organization [WHO], 2014: 2). The highest number of alcohol-attributable deaths comes from a variety of diseases and conditions such as cardiovascular diseases, unintentional and intentional injuries, gastrointestinal diseases and cancers (WHO, 2014: 48). The proportion of alcohol-attributable deaths to all deaths is highest in the European WHO region (including Russia and eastern Europe), in which 13.3 percent of deaths were attributable to alcohol. In the Americas WHO region (including North, Central and South America) 4.7 percent of deaths were attributable to alcohol, which is lower than the global average of 5.9 percent (WHO, 2014: 49). The WHO global strategy, which was endorsed by the World Health Assembly in 2010, shows that globally alcohol is recognized as a contributor to negative health, social and economic outcomes.

The global problem attributable to alcohol insists that governments look for evidence-based policies to reduce harm. The SAPM, although its original inputs and outputs were focused on the UK, provides any jurisdiction with the framework to estimate the effects of different policy options. In fact, the SAPM has already been adapted to all countries of the UK (England, Scotland, Wales and Northern Ireland); in

addition, outside of the UK the pricing strategies, such as the minimum unit price, of SAPM have been adapted and estimated to two Canadian provinces (Ontario and British Columbia) (Hill-McManus et al., 2012) and to the Republic of Ireland (Angus et al., 2014). The screening and brief intervention model of the SAPM has also been adapted to Italy (Struzzo et al., 2014).

The Canadian adaptation of the SAPM was published in a report in December 2012. The report includes the methods and results of scenarios of pricing policies in Ontario and British Columbia. The appraisal was the result of a collaboration of researchers from the Sheffield Alcohol Research Group (SARG) at the University of Sheffield, the Centre for Addictions Research of British Columbia (CARBC) at the University of Victoria and the Centre for Addiction and Mental Health (CAMH) at the University of Toronto. Specifically, the report underlines the minimum price policy tool and how it would compare to a general price increase on alcohol. Just like the UK's adaption of the SAPM, the researchers used Canadian alcohol consumption survey data, cost, crime and labor force data to estimate the outcomes from certain policies. They found that for a policy of a minimum unit price of $1.50 CAD, there would be a drop in alcohol consumption population-wide by 1.43 percent in Ontario and a drop by 1.36 percent in British Columbia. Overall, hospital admissions would fall in the first year by 1,393 in Ontario and by 244 in British Columbia. Number of deaths in the first year would be projected to fall by 31 in Ontario and 39 in British Columbia. The study concludes with a discussion about the desire to expand the model of the SAPM in Canada to evaluate more pricing policies with more appropriate data (Hill-McManus et al., 2012).

The limitation of alcohol taxes in Canada, as the report identifies, is that they are usually based on volume of liquid rather than pure alcohol content, which is the same as in the United States. To conclude, the report proposes that minimum pricing in Canada should be considered a public health policy that policy makers should pursue to relieve the harmful effects of alcohol (Hill-McManus et al., 2012).

Similarly, a report published in September 2014 adapted the SAPM to the Republic of Ireland. The report modeled a series of minimum unit prices to calculate their expected impacts. In addition to pricing strategies, and unlike for Canada, the model also adapted policies of bans on below-price selling including promotions. The Irish report came from a commission in 2013 by the Irish government to the Sheffield Alcohol Policy Research Group (SARG). Using Irish specific data, the model generated results for pricing schemes, with a focus on the minimum unit price (Angus et al., 2014: 13). The report highlights the minimum unit price policy of €0.90, which would raise the price of over a third of drinks in Ireland. With the policy, weekly consumption of alcohol would fall by 6.2 percent, in the first year there would be 1,582 fewer hospital admissions, and 52 fewer deaths (Angus et al., 2014: 51, 67-70). The report concludes that in Ireland a minimum unit price would be effective at reducing alcohol consumption and alcohol-related harms. They also consider the equity of the policy, which they say would have the largest consumption change among drinkers in poverty; however, the savings from lower spending on alcohol and health gains would help reduce the unequitable impact of the policy (Angus et al., 2014: 77). Apart from the modeling and application of the Sheffield

Alcohol Policy Model to other areas, related legislative action has been taken to address alcohol use.

The strength of the SAPM is that it shows how a wide range of policy options can limit the consumption and harm caused by alcohol use. The model provides a quantitative analysis upon which policy makers can make unbiased decisions. Since the SAPM has been applied to many countries that are concerned about the role of alcohol in health, crime and workplace outcomes, the results offer a strong opportunity for actual policy legislation. In fact, in the UK in particular, the SAPM has informed policy agendas regarding the specific policy of the minimum unit price. However, sometimes private and political interests can get in the way of the policies best for public health. On the SAPM website, for example, they report that the UK Government has abandoned its policy idea of the minimum unit price. Instead, in Wales and England in 2014, a ban was put on below-cost sale of alcohol (a cost derived from the product's duty and its value-added tax [VAT]) (Sheffield Alcohol Research Group [SARG], 2018). Such a policy, as the SAPM evaluated, would only have a small reductive effect on consumption and harm of alcohol use and is not as powerful as the minimum unit price (SARG, 2018). Unlike the story in England and in Wales, the agenda of public health can prevail, as happened in Scotland.

The success story of SAPM is that it helped create legislation in Scotland, where after more than five years of political and private battle, the minimum unit price was implemented in May 2018 (Scottish Government, 2018). A series of appraisals made to the Scottish Government from 2009, 2010 and 2012 adapted the SAPM to the Scottish population and market. As a result, and a commitment on the part of public health, a

minimum unit price on alcohol was introduced in the Alcohol (Minimum Pricing) (Scotland) Act 2012 and passed by Scottish Parliament in May 2012 (Scottish Parliament, 2012). Following, however, the minimum unit price policy was challenged by private interest groups, including the The Scotch Whisky Association. In November 2017, the UK Supreme Court ruled in favor of the minimum unit price. Finally, the policy of a £0.50 minimum unit price on alcohol was decided on and implemented on May 1, 2018 (Scottish Government, 2018). The Scottish history shows that the research of the SAPM can inform policy makers on the costs and benefits of alcohol taxation in order to make public policy. Due to the length of time the policy took to become implemented, we see the amount of resistance to alcohol price controls that special private interest groups have. The eventual passing of the policy shows the persistence of Scottish policy makers in seeking to decrease the prevalence of harmful alcohol-related outcomes.

In all, the SAPM offers an adaptable model for researchers to predict the effects of pricing policies on alcohol consumption and related harms. SAPM also offers a great opportunity for policy makers dedicated to public health to propose pricing policies to limit the availability of alcohol. Outside of the research and policy generated by the SARG and the researchers that have already applied SAPM, a wide range of literature has been published on the public health issue of alcohol use and abuse. Econometric studies offer peer-reviewed evidence on the topic of alcohol pricing strategies and their effects. In particular, studies that make use of different U.S. state-by-state policies of alcohol taxation are common. Due to the ability of states to levy and control their own taxes, the opportunities for research are numerous.

2.2   Research on Alcohol Taxes and Public Health Outcomes

The variety of literature available surrounding the topic of alcohol taxes and health outcomes is abundant. Sin taxation policies are policies of taxation on goods whose consumption cause harm; sin taxes have often been studied and offered as public policies for two major reasons that appeal to policy makers: 1) a rise in a sin tax may decrease consumption of that good, and therefore decrease its harmful effects in the population, and 2) higher taxes generally raise government revenue (Goldman, 2016). Throughout this review of the available literature, I will be concentrating on research to answer appeal number one (1) due to my concentration on public health and not on government revenue, although the Sheffield Alcohol Policy Model (SAPM) addresses both. Does, and to what extent, a taxation policy on alcohol affect its consumption and the harms attributable to its use and abuse? The SAPM thoroughly answered this question through modelling future consumption and harms attributable to alcohol. Regardless, it is important to look for other results; firstly, because the SAPM has not been applied to the United States. Additionally, because varied types of taxation applied to different populations could have different effects and to well inform public policy it is essential to understand all the possibilities.

In policy to limit alcohol use, the mechanism of taxation is shown to be an important tool by the literature. An article published in *PLoS Medicine*, written by researchers from the Sheffield Alcohol Research Group (SARG), introduced, assessed and concluded results on four different types of alcohol pricing policies. The four methods of taxation on alcohol they investigated include: a tax increase for all products; a

value or price based tax (also known as ad valorem); a volumetric tax based on the alcoholic strength of the product; and a minimum unit price (Meier et al., 2016). The study, which relied heavily on the mathematical approach of the SAPM, compared the four taxes at rates that would achieve the same 4.3 percent reduction in alcohol-related mortality. In terms of consumption of alcohol, all policies were shown to cause reductions in all populations of drinker groups; however, the volumetric and the minimum unit price reduced most heavily the consumption of the heavy drinkers (Meier et al., 2016). It is important that heavy drinkers are affected most because their habits put them at the highest risk of health harm. The same policies, the volumetric and the minimum unit price, reduced by the least amount the consumption of moderate drinkers (Meier et al., 2016). Spending on alcohol would increase under most tax schemes for most income levels; the exception is the volumetric tax, which would decrease spending in lower income groups. Similarly, in alcohol-related mortality the volumetric and the minimum unit price would cause the largest reductions in particularly heavy drinkers in the "routine/ manual" occupation group (Meier et al., 2016). They conclude that in terms of equity, the volumetric tax and minimum unit price would reduce inequalities of health harms most (Meier et al., 2016). This article shows that it is important to understand the different types of taxation because not all produce the same effects.

A similar article published in *Alcohol and Alcoholism* created another model to gauge the effects of different methods of alcohol taxation. Their paper modeled specific taxes (referred to in the previous article as the volumetric tax), ad valorem taxes and a combination of both to examine the tax burdens on different quantities of alcohol. They

did so by simulating 100 different alcoholic beverages with different contents of ethanol to which the different taxes were assigned (Sornpaisarn, 2015). The specific tax created an equal burden per unit of ethanol for each drink, whereas the ad valorem based its tax on the product's price. The ad valorem tax created an incentive to produce lower beverage prices per unit of alcohol, which in turn would increase consumption. The article draws attention to the importance of incentives when designing an alcohol tax policy. The policies of taxing price and taxing alcohol content yield different outcomes. It is therefore essential for governments and policy makers to understand the differences in order to create policies to reduce the societal outcome they seek to amend.

Research using different types of taxation shows the effects that the policies can have on outcomes such as consumption and health harms. A report from 2016 estimated the expected effects of increasing excise taxes on alcohol in Texas. The model is similar to the SAPM in that it calculates the effects of certain taxes on changes in alcohol consumption and health outcomes. Alcohol-related harms measured in the report include mortality, by traffic accidents for example, and teen pregnancy (Diaz et al., 2016). In this model, excise taxes are taxes added to existing prices; they are considered from five to thirty cents. In all, the policies are shown to reduce consumption of alcohol-related harms; in particular, they found a steep increase in reductions of harms above the tax amount of ten cents (Diaz et al., 2016).

Similarly, a study published in *PLoS ONE* that analyzed alcohol tax policy changes in Hong Kong gives another overview of the health harms of alcohol and how targeted taxes can affect them. The peculiarity about this study is that it measured

alcohol-related mortality from 1981 to 2010, over which time there were multiple

changes to alcohol taxes, including increases and cuts. After the first tax cut in 1984, they

noted an increase in acute alcohol-related mortality, which they said could be in part due

to the cheaper and more abundant alcohol. Contrarily, an alcohol tax increase in 1994

coincided with a decreased risk for alcohol-related mortality (Chung et al., 2014). The

article does not make any causal claims about alcohol taxes; however, the article does

claim that the supplies of alcohol did correspondingly change with the taxes. For

example, after 1994's tax increase there was a decline in the imports of alcohol (Chung et

al., 2014). Overall, alcohol has been linked to many harms and many studies have

evaluated the role of taxes in controlling those harms. There have also been a series of

studies on the role of alcohol taxation and its effects on specific outcomes. Out of my

review of the literature, studies have looked at specific outcomes of alcohol consumption,

traffic accidents, sexually transmitted diseases and health care spending and

hospitalization and how alcohol prices can affect them. All of these outcomes are

included in the SAPM. Other non-health outcomes such as crime and workplace harms,

which are included in the SAPM, are excluded from my review of the literature because

they do not specifically relate to my research into public heath harms, although they are

an important factor to consider for further research.

The pathway between alcohol and alcohol-related harm is through its

consumption; that is to say, the intermediary factor of any outcome attributable to alcohol

is short-term (acute) or long-term (chronic) alcohol use. The SAPM also addresses this

pathway through its models component one (1) function: intervention to consumption. In

2009 a systematic review was published in *Addiction* that summarized 112 studies that related alcohol prices to consumption. The review compiled these studies in order to obtain an average elasticity of alcohol, broken down into beer, wine and spirits. Elasticity of consumption defines how much will the population's consumption change if the price changes by a certain amount. The elasticities they find are -0.51 for all alcohol, -0.80 for spirits, -0.69 for wine and -0.46 for beer. These negative figures of elasticity show that the consumption of alcohol falls when its price is higher (on average, as the study finds, if alcohol prices rise 10 percent then its consumption falls by 5.1 percent) (Wagenaar et al., 2009). Another more recent study, which was published in *The American Journal of Drug and Alcohol Abuse*, looked specifically at an alcohol sales tax increase in Maryland and how it impacted alcohol sales. Studies on alcohol sales can be used as a fair proxy for alcohol consumption, although data for sales may be more reliable because it is obtained from official numbers rather than the self-reporting data used for alcohol consumption. The study found that from before to after the 2011 increased sales tax, beer and wine sales increased, while spirits sales decreased. Using regression controls to calculate expected sales without the increase, and using a standardized measure for units of alcohol, they found that the tax was associated with a 3.8 percent decline in sales of alcohol overall (compared to the no policy scenario) (Esser et al., 2016). Commonly, both studies point to associations among higher prices of alcohol and lower consumption and spending. In discovering the current literature on the effects of alcohol pricing, I now direct my review to outcomes included in the second component of the SAPM: the consumption to outcome function.

2.2.1 Research on Health Outcomes

In the Sheffield Alcohol Policy Model (SAPM) one of the included alcohol-related health outcomes is road traffic accidents. The event is considered by the framework to be a partially attributable acute condition; this term means that the event can occur without the use of alcohol but the risk of occurrence increases with only short-term (acute) alcohol use. A cross-sectional study of tax policies across all states was published in 2018 in an article in *JAMA Internal Medicine*. The study concentrated on how the restrictiveness of states' alcohol policies can affect alcohol-related motor vehicles crashes (ARMVC's) resulting in fatalities. They conducted their experiment by creating an aggregated rating (known as the Alcohol Policy Scale [APS]) that combined the state's laws for alcohol control, such as alcohol tax policies and sobriety checkpoints. In all they found that a more restrictive policy environment, or a higher APS, reduced individual level and overall odds of fatal motor vehicle accidents being alcohol-related (Naimi et al., 2018). This country-wide study suggests that greater control on alcohol has a reductive effect on its harms on the road. The study does not however attribute the reduction to any single policy, but rather to the policy environment overall. Instead, the following included studies look at the effects of specific alcohol tax policies on varied outcomes.

A study published by the *American Journal of Preventive Medicine*, evaluated the same 2011 alcohol sales tax increase studied by Esser et al., 2016. Instead of expenditures on alcohol the authors (Lavoie et al.) examined how the increased tax affected rates of non-fatal and fatal alcohol-related motor vehicles crashes (ARMCV).

The study used data from the Maryland Automated Analysis Reporting System to obtain information on car crashes from 2001 to 2013 (127 months before and 29 months after the tax increase). The results found that there was a gradual reduction in non-fatal and fatal ARMCV's from before the tax to after. The study however did not conclude its hypothesis that the tax had a statistically significant impact on reducing crashes (Lavoie et al., 2017). In the youngest age group, drivers 15 to 20, the decrease was 6 percent, although it was not significant. However, they found that in the oldest age group of drivers, 55 and over, there was a significant increase in crashes (Lavoie et al., 2017). The results do not point to a causal relationship among the sales taxes and reduced morbidity and mortality from alcohol use. Instead of the sales tax on alcohol, the following studies look at different types of alcohol taxes to determine how they affect health harms.

In 1999 and then in 2009, the State of Illinois raised its alcohol excise tax. A report published by the Urban Institute & Brookings Institution in 2017 analyzed both of the tax increases for any evidence that they reduced alcohol-related motor vehicles crashes (ARMVC's) resulting in fatalities. The report used a synthetic control method[1], along with Fatal Analysis Reporting System (FARS) data and economic data for controls, to evaluate the effect of the two interventions in Illinois. The study found that neither tax increase led to sustained long-term declines in alcohol-related fatalities on the road. Interestingly, however, they did find a temporary drop in such fatalities in Illinois counties post-2009 that do not border another state (McLelland and Iselin, 2017). This

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[1] An econometric specification in which a control area that does not receive the intervention is generated synthetically; more information available from Craig, 2015

result may show that in counties further from other states there were fewer options to avoid the Illinois tax. In all, this study was unable to find evidence for the relationship among taxation and traffic fatalities; however, it introduces us to the idea that alcohol tax policies have less of an effect when consumers can easily avoid taxes by buying alcohol from nearby states.

Separately, the same Illinois alcohol excise tax increase in 2009 was studied in another article published in 2015 in the *American Journal of Public Health*. The study used an interrupted time-series design to find any relationship among the tax increase and ARMVC's involving fatalities. The study used non-alcohol related crashes and non-Illinois data to control for trends that the tax would not have affected. Comparing the true values of post tax-increase months and a predictive model supposing no tax change, they found that after the tax ARMVC's with fatalities fell by 9.9 crashes a month, or by 26 percent (Wagenaar et al., 2015). Unlike the Brookings report, this study found that the tax increase had a large positive impact on reducing traffic incidents related to alcohol. The studies are not entirely comparable however, because they did not use the same dependent outcome; that is, the Brookings report measured fatalities by ARMVC's, whereas the Wagenaar et al. study measured the actual crashes. Another study, from outside of the United States, measured the effect of alcohol excise taxes on overall ARMVC's in Estonia from 1998 to 2013. Over the time period, alcohol excise taxes had changed ten times. The study found a statistically significant result that a one-unit increase in the tax rate was associated with a 1.6 percent decline in the rate of accidents involving drunk-drivers (Saar, 2015). The author of the study discussed the high

magnitude of their result but suggested that considerations should also be given to omitted variables other than policy changes, including road conditions and other alcohol regulations, that would have affected drunk-driver accidents.

Another harmful outcome that has been studied to be affected by alcohol taxes is sexually transmitted infections. Two separate studies looked at different forms of alcohol taxes in Illinois and Maryland and their effects on rates of chlamydia and gonorrhea. The study on Illinois looked at the excise tax increase in 2009; they concluded that the gonorrhea and chlamydia rates both fell after the tax increase (Staras et al., 2014). Similarly, the study on the 2011 alcohol sales tax increase in Maryland found substantial decreases in chlamydia; however, the study did not find that rates of gonorrhea were affected (Staras et al., 2016). These studies show us that the effects of alcohol use are seen through many societal outcomes. Research into this topic helps us to understand the full threat of alcohol use and if and how tax policies can reduce that threat. In addition to studies on specific health outcomes such as motor vehicle accidents and sexually transmitted infections, societal harm of alcohol comes in the form of excess medical spending and hospitalization for alcohol-related conditions.

2.2.2 Research on Spending and Hospitalizations

Two studies, both with the focus area of Taiwan, looked at alcohol tax policies and how, or if, they affected the medical system. Taiwan has had a single-payer health care system since 1995, which covers nearly the entire population. This standardized system allowed both studies to use Taiwan's public National Health Insurance Research

Database for their research (Chen et al., 2011). The first study, (Lin and Liao, 2014),

looked at how changing tax policies affected inpatient expenditures on alcohol-attributed

diseases. They found an abrupt drop in quarterly hospital inpatient charges (14.8 percent)

following the implementation of a tax increase, which was sustained for several years.

(Lin and Liao, 2014). The 2017 article, written by the same authors, looked at the global

recession of 2008 and a reduction in alcohol tax to examine how it affected

hospitalization from alcohol-related diseases. They found that following the crisis and the

tax decrease, rates of hospitalizations among lower and higher income men in Taiwan

increased. Although the study did not look at time over which the tax policy changed, the

article mostly discussed the effects of lower income and unemployment affecting mostly

men of low-income (Liao and Lin, 2017). Since Taiwan's health care is publicly

financed, it is important for its government to lower spending in its hospitals. Although

the studies do not directly look at harm from injury and fatality, they do focus on

expenditures and hospitalization, which positively correlate.

2.2.3   Research on Subpopulations

Many alcohol taxes have been studied for their effects at the population-wide

level; whereas others have hypothesized that the effects of alcohol taxes are based on age,

race and ethnicity and socioeconomic status. A paper published in *Health Policy*

reviewed 45 studies across nine countries in which some alcohol policy change occurred

between 1989 and 2010, including tax changes or new age restrictions (Nelson and

McNall, 2016). The results of their comprehensive review revealed that alcohol price

restrictions have mixed effects on alcohol-related harms. The authors attributed the result

to "nuanced effects" of alcohol policies on subpopulations (Nelson and McNall, 2016). In

other words, this study set the idea that alcohol taxes do not affect everyone in the same

way.

To prove this, other researchers examined how policies of alcohol tax can affect

the different groups in terms of consumption and harm. An article from *Pediatrics*

analyzed all of the United States to see how responsive youth are to policy environments

regarding alcohol. Using author-quantified ratings of alcohol policies and the Youth Risk

Behavior Surveys, the authors were able to find any associations among policies and

changes in self-reported youth drinking and binge drinking. The results showed that a 10

percent greater alcohol restrictive policy environment was associated with an 8 percent

reduction in youth drinking and a 7 percent reduction in binge drinking (Xuan, 2015).

These results suggest that youth are very responsive to price changes. An article from

Alcohol Research & Health reviewed studies on prices of alcohol and how it affected

youth consumption, health harms and violence. The study claims a similar result in that

prices and tax policies affect outcomes in youth; they also suggest that variations might

also occur by gender and race (Chaloupka et al., 2002).

A previously mentioned study, Staras et al., 2014, on the Illinois excise tax

change looked at how STI rates changed and if that change was age or race and ethnicity

based. They found statistically significant results concluding that the effects were

associated with demographic factors. In summary, the article said that in subpopulations,

such as non-Hispanic blacks, that have high disease burdens, alcohol taxes can produce

strong reductions in STI's (Staras et al., 2014). Within the literature there are also studies that have looked at different effects of alcohol taxes based on socioeconomic status. A previously mentioned studied, Liao and Lin, 2017, on hospitalizations due to alcohol-related diseases looks at the effects based on income. Their study found that income played a role in people's alcohol buying behavior and their subsequent hospital use (Liao and Lin, 2017). Another article from Finland looked at alcohol taxes and minimum prices and their effects based on income and occupation. The first part of their study looked at a 2004 cut in alcohol excise taxes in which taxes were cut by one-third of their value. By comparing pre-intervention and post-intervention data they found that income was a statistically significant factor in differential alcohol-related mortality. The study also made use of Finland's minimum prices implemented in their state-owned liquor stores; in studying those set prices and how they changed, they found that minimum price changes have statistically significant effects on mortality only in men with "basic" (i.e. the lowest level of) education (Mäkelä et al., 2015). We see through these two studies that factors of socioeconomics are impactful when studying the effects of alcohol tax policy. The need to study such differences is important in order to create policies to achieve an equitable result.

The literature provides a good setup for my own research. The Sheffield Alcohol Policy Model (SAPM) sets a thorough framework to describe the pathways through which tax interventions affect alcohol-related outcomes. The estimates of the model and its applications in its country of origin of England and abroad provide the opportunity for a similar policy framework to be applied and ultimately considered in the United States.

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Literature too from outside sources that performed similar studies on alcohol taxes inform my research. The studies described in this review looked at alcohol and its taxation and how, around the world, that has or could affect consumption and harmful, costly outcomes. Since the SAPM is based in a highly mathematical forecasting approach, I often referenced the non-SAPM studies in own design. The review of the literature serves the purpose to inform my research in constructive ways; it can also serve to inform policy makers and researchers on the wealth of information on the limiting of alcohol-related harms through alcohol taxation. I hope that through my individual research and findings will help contribute to that information to push forward purposeful taxation policy to support public health.

Chapter 3

METHODOLOGY

3.1   Theoretical Model

Alcohol consumption and alcohol abuse are linked to harmful societal outcomes through mathematical models and numerous peer-reviewed studies. The Sheffield Alcohol Policy Model (SAPM), developed under a commission by the Department of Health in England, is a mathematical model informed by data and research that estimates the societal consequences of alcohol. Firstly, the SAPM shows that alcohol consumption creates negative health outcomes of morbidity and mortality. In terms of policy, the SAPM estimates the effects of alcohol taxation and how it can be used to change these negative societal impacts (Brennan et al., 2008b). Due to my interest in reducing the harmful effects caused by alcohol use and abuse, I chose to use the SAPM as a framework to study how policies of taxation can reduce the effects of alcohol. Throughout the study, I try to adhere as closely as possible to the model created in the SAPM. I came to focus on the excise tax on alcohol, which is described by the literature and by the SAPM. In determining a research question that would satisfy my interest in alcohol taxation policy and its effects on a health outcome, I chose to look at road traffic accidents. Road traffic accidents attributable to alcohol is a health outcome that is included in the modeling of the SAPM. It is also important for me to look at alcohol-

related road traffic accidents because it affects a large amount of people; alcohol-related accidents cause harm to not just those who choose to drink and drive, but to those who are in the same car and to all cars and pedestrians on the road. To carry out my research and best apply the framework of the SAPM, I needed to identify an area with some implemented tax policy intervention to study with rich quantitative data to describe traffic accidents.

3.2   Tax Policy and Selection of Area

To run an experiment on alcohol taxes, I had to first identify a geographic area in which a change in an alcohol tax created a suitable intervention environment to study. Since the Sheffield Alcohol Policy Model (SAPM) has never been applied to the United States, I found it important to use the U.S. to apply similar concepts. The advantage to using the United States as a county of interest is that there are many different policies of alcohol taxation. Since alcohol taxation is largely a state's power, each state can control and levy taxes on alcohol. For this reason, apart from broad federal regulations on alcohol, each state and Washington D.C. has different alcohol tax policies (Distilled Spirits Council of the U.S., Inc [Distilled Spirits Council], 2015). To assist me in finding a state policy intervention appropriate for analysis, I found a report from 2015 titled "History of Beverage Alcohol Tax Changes, 2015" by the Distilled Spirits Council of the U.S., Inc. In their report, federal tax changes and state-by-state tax changes are listed chronologically, by alcohol type (distilled spirits, table wine and beer), and by the specific taxation instrument (including excise tax, sales tax and local taxes). I was

confident in using this report for initial identification of a state and policy because it standardized information from a large amount of federal, state and local government published and verified sources.

In order to find a state and a time period to research, I first looked at the federal laws that governed all states; in other words, I needed a time period in which a state alcohol tax policy change was sufficiently distant in time from any federal change to more safely attribute effects to the state policy. Federally, the most recent change to alcohol taxes was in 1991 under the Omnibus Budget Reconciliation Act of 1990 (Distilled Spirits Council, 2015: 2). Assuming that tax policy effects are at their full effect five years after implementation, any policy change suitable for study to me must have been implemented ten years after 1991 (5 years after the federal policy and 5 years before any state policy to allow for sufficient pre-tax years). In short, my window for any alcohol tax change was from 2001 to 2011 (assuming 2016 would be the most recent year available for data), allowing time for enough pre-tax results and post-tax results.

The Distilled Spirits Council report details changes to different types of alcohol taxes, but I chose to examine a change in an excise tax because of its identification by the SAPM. A SAPM paper by Meier et al., 2016 discussed and modeled different policy strategies that governments use or could use to tax alcohol. About taxation strategies they said:

> volumetric taxation (a tax based on product strength or quantity of alcohol) and minimum unit pricing (a tax floor, or minimum price per quantity of alcohol) consistently outperform increasing the current tax or adding an ad valorem tax (a tax based on product price) in terms of reducing mortality among the heaviest drinkers and reducing alcohol-related health inequalities (Meier et al., 2016).

I used this SAPM finding, therefore, to limit my selection to either of two types of taxes: volumetric taxation or minimum unit pricing. Evidently, from the report on tax change history, states that implement excise taxes do so based on some quantity such as gallon, liter, barrel or container of alcohol (Distilled Spirits Council, 2015). Although a tax based on the quantity of liquid may not correlate perfectly to the quantity of alcohol (i.e. quantity of ethanol), such as alcohol by volume (ABV), which is the definition used by Meier et al., it provides the next best option for study. The minimum unit price has not been applied in the United States, which would have provided an excellent application of the SAPM framework. In its absence, and the identification in the literature of the volumetric tax as a potent policy, I made the decision for the next-best option: the volumetric, or excise tax. I therefore had to find a state that implemented some intervention of an excise tax on alcohol to study.

With use of the Distilled Spirits Council's report to look for states that had changed an excise tax from 2001 to 2011, I ruled out all but twelve of the fifty states to examine further. The next selection criterion was to pick one of these states that at the same time levied a tax change on all types of alcohol (distilled spirits, table wine and beer). The reason for this is that data on outcomes would unlikely identify the *type* of alcohol consumed, but rather that *some type* of alcohol was consumed; using a tax that was levied on all types of alcohol would avoid the uncertainty. With that selection, just six states remained that changed an excise tax from 2001 to 2011 on all types of alcohol. To further reduce the selection, I looked for states that had changed their alcohol excise taxes by a standard amount for every type of alcohol. The reason for this is again that the

data would likely not differentiate effects by one alcohol over another. It would be more statistically suitable to look at a 10 percent change of the excise tax on all types of alcohol rather than a 10 percent change on distilled spirits and table wine but a 20 percent change on beer, for example.

The remaining states were the States of Connecticut, Nevada and Tennessee. Nevada, in August 2003, raised its excise tax per-gallon on all types of alcohol by approximately 75 percent. Since the policy's implementation in Nevada, however, there have been increases in the state's and counties' alcohol sales tax (Distilled Spirits Council, 2015: 32). Tennessee, in July 2002, raised its excise tax on all types of alcohol by exactly 10 percent. In Tennessee, however, a new local tax on wholesale beer was levied more recently (Distilled Spirits Council, 2015: 46). On the other hand, Connecticut raised its excise tax on all types of alcohol in July 2011 by exactly 20 percent. Connecticut raised its sales tax on alcohol at the same time, but only by 0.35 percent (Distilled Spirits Council, 2015: 10). After that July 2011 implementation in Connecticut, there have been no more alcohol pricing policy changes.

In the end, among the three states I chose to use Connecticut. Firstly, since the most recent tax change in Connecticut was the excise tax on all types of alcohol, the data would be less likely to represent changes from policies other than the excise tax. Secondly, I preferred more recent tax changes because it would make it more comparable to the environment of today. Thirdly, and as shown in my review of the literature, to my knowledge there have been no studies of the effectiveness of the July 2011 tax increase in Connecticut, whereas similar policies in other states have had such studies.

With the selection of Connecticut, and the benefits of its suitable test environment, I needed to confirm the exact policy that would form my independent variable. I therefore searched for state specific information. A policy analysis published by the Office of Legislative Research of the Connecticut General Assembly in August 2011 clarified that on July 1, 2011 the per-gallon excise taxes on liquor (distilled spirits), wine (table wine) and beer, were unilaterally raised by 20 percent. That is to say, the excise tax on liquor was raised from $4.50 to $5.40 per-gallon; on wine from $0.60 to $0.72 per-gallon; and beer from $0.20 to $0.24 per-gallon (Lohman and Pinho, 2011). The report also said that prior to 2011 Connecticut had not changed its alcohol tax since March 23, 1989 (Lohman and Pinho, 2011).

3.3   Measurement of Health Outcome and Data

The next step in the development of my research question was the identification of a societal health outcome attributable to alcohol use that has been well measured. To apply the theory of Sheffield Alcohol Policy Model (SAPM) most closely, I reviewed the health conditions that the model used. I concentrated on conditions that were defined as attributable to the acute use of alcohol. I was not interested in chronic use of alcohol because chronic use can be caused by many complex factors over a long period of time; on the other hand, acute alcohol use may represent just one event of alcohol consumption. Through the conditions that the SAPM categorizes as "Partially acute attributable conditions" I was interested in focusing on road traffic accidents (Brennan et al., 2008b: 71). Drivers that are under the influence of alcohol are a threat to everyone on the road: to

themselves, to their passengers, to other cars and to pedestrians. The Centers for Disease Control and Prevention also highlight the role of traffic accidents in acute conditions related to excessive alcohol use (CDC, 2013). It is reasonable to choose traffic accidents attributable to alcohol as a health outcome to measure in applying the concepts of the SAPM as it negatively impacts society.

A large amount of literature outside of the SAPM has used traffic accidents as a dependent variable in research on alcohol. Such studies relating traffic accidents to alcohol prices and taxation are included in my review of the literature. Four studies included in the literature review examine the effects of alcohol taxes on motor vehicle accidents related to alcohol use; two of which use the same public source for data. In order to answer their different research questions, the two studies used the U.S. National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS) (McClelland and Iselin, 2017; Wagenaar et al., 2015). One study on the effects of an alcohol sales tax change in Maryland uses a similar Maryland specific database, the Maryland Automated Analysis Reporting System (Lavoie et al., 2017). The fourth study was from Estonia but used, just as the other three studies, an administrative database containing road reporting data (Saar, 2015). I therefore favored FARS, as it was trusted by other researchers of multiple studies related to my interests, and for its extensive country-wide data.

The Fatality Analysis Reporting System (FARS) is a comprehensive database that includes data on all crashes since 1975 that involved fatalities occurring in all fifty states, the District of Columbia and Puerto Rico (NHTSA, 2017). The entire data set includes

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over 100 variables spread across 20 data files that are coded by the National Highway

Traffic Safety Administration from state accidents reports. Three data files have been

kept every year since 1975, which include information on accidents, vehicles and un-

identifying information on the people involved in each accident (NHTSA, 2017). This

data will provide me with the information I need to come to conclusions on the ability of

the Connecticut alcohol tax policy to change the harmful effects of alcohol-related motor

vehicle accidents.

3.4   Research Questions

With the information provided in the FARS database, I was able to create a

dataset with which to test my research questions and hypotheses and reach conclusions

about the 2011 alcohol tax policy change in Connecticut. My framework of the Sheffield

Alcohol Policy Model (SAPM), the current literature available and the data available for

research turned me to form my first and main research question as follows:

(1) What was the effect, if any, of Connecticut's 20 percent increase of its alcohol

excise tax on July 2011 on monthly morbidity and fatality by alcohol-related

motor vehicle crashes?

The main research question addresses the dependent variable of health outcomes of

morbidity and fatality that are considered in the SAPM. Using the rise in the alcohol

excise tax as an independent and nominal variable, the FARS data will help reveal

monthly morbidities and fatalities related to a drinking driver. Analyzing this will allow me to see any trends in incidents per month. I hypothesize that, after the tax change creating a higher price on alcohol, monthly morbidities and fatalities from alcohol-related motor vehicle crashes will fall. I come to this hypothesis with support by the model results of the SAPM, which show an immediate decrease in acute health illnesses from most modeled alcohol tax policies (Brennan et al., 2008: 126), and another mathematical SAPM paper which estimated a reduction in alcohol mortality from modeling different alcohol pricing policies (Meier et al., 2016). Evidence in the literature with similar research questions about motor vehicle accidents also points me to forming my main hypothesis; some studies conclude results that alcohol taxes have a negative effect on health-threatening outcomes on the road, such as Lavoie et al., 2017, Saar et al., 2015 and Waagener et al., 2015. Other studies, however, could not find significant effects of taxes on health outcomes on the road, such as McClelland and Iselin, 2017.

Secondly, after having asked the first research question, I find it important to ask about more nuanced effects of the Connecticut alcohol tax policy. The SAPM also has a focus on the effects of alcohol pricing policies on underage drinkers (Brennan et al., 2008: 21). In following the SAPM's lead, I ask through my second research question the differential effects of the policy on people under the legal age to drink (21 years of age):

(2) Is the effect found from research question 1 different for drivers under the legal drinking age?

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The effects of alcohol policies have also been considered to have varying effects by age by three different studies included in the literature review (Xuan et al., 2015; Staras et al., 2014; Chaloupka et al., 2002). Apart from research in the literature, economic theory would suggest that alcohol prices should have different effects on people of different incomes. Younger people, and especially minors and dependents, will likely have less independent income. This income effect should combine with the already present difficulty of acquiring alcohol underage. I therefore hypothesize that the effects will be greater of the tax increase on morbidity and fatality by alcohol-related motor vehicle crashes of drivers under 21 years of age.

3.5   Data and its Operationalization

In order to answer my research questions, I had to prepare the data for analysis. The FARS files that will help me answer my research questions are the Accident and Person data files, which I downloaded from years 2000 to 2016 as raw data found through the public FARS website portal.[2] Having merged the two different data files across all seventeen years, I ended up with a massive data file including all persons involved in all crashes ending in a fatality in the entire United States from 2000 to 2016 (n= 1,501,096; 149 variables) including the State of Connecticut (n= 10,847). Since my research questions were on monthly crashes, and the FARS data set included observations of people, I had two necessary steps of data aggregation (people aggregated

[2] https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars

to crashes and crashes aggregated to months) to arrive at my final data set for analysis. New variables were also necessary to create at each step to gather pertinent variables that would too become aggregated and included in my final data set.

The first data set showed observations per person. With reference to the FARS Analytical User's Manual (FARS, 2017), I started to manipulate and operationalize the variables that already appeared in the data set to create variables that would be help me answer my research questions. Firstly, I used the FARS variable of the blood alcohol content (BAC) level, which would have been a test administered to the person. The values of the variable that correspond to a BAC level of 0.08 percent (0.08 g/dL) or higher, Connecticut's legal drinking and driving limit (Frisman, 2016), were used to indicate someone's drinking status. For drivers under 21 the stricter Connecticut BAC legal limit of 0.02 percent (Frisman, 2016) was used. The identification of a driver with a BAC at or above the limit will operate as the sole indication of an alcohol-related motor vehicle crash; that is, only if the driver was reported to have an illegal BAC level at the time of the crash would I define that crash as alcohol-related. Then, to further describe the driver, I created a variable that would be useful to answer research question two; I had to form another binary variable identifying underage drivers. Using FARS variables including role and age of the person I was able to construct the variable. Therefore, if the person was a driver *and* was under the legal age for drinking they were considered an underage driver.

To capture if the person was injured, I had to create a binary variable that combined the FARS information about injury severity. I operationalized injury as an

outcome of four categories of injuries given by FARS: Incapacitating/ Suspected Serious Injury, Non-Incapacitating Evident/ Suspected Minor Injury, Possible Injury and Injured, Severity Unknown. A similar operationalization of injury was used by Lavoie et al., 2017, supporting the operationalization of my newly created variable. Similarly, I created a new variable to capture if the person died, using the same FARS variable on injury severity. The resulting data set after the addition of the four new variables included 153 variables.

At that point, I could proceed to the first level of data aggregation. In order to obtain one observation per crash I had to aggregate the observations on people into one observation per crash. The resulting data set presented each crash with its number of injuries and fatalities and if one of the drivers involved was drinking and/ or underage for the entire United States (n= 589,574; 9 variables) including the State of Connecticut (n= 4,571). Next, I created interval variables to serve as my dependent variables of injuries and fatalities by alcohol-related motor vehicle crashes. These variables would only be greater than 0 if the driver was reported to have alcohol involvement. In other words, even if the crash resulted in injury and/ or fatality but the driver was not drinking, this variable would have a value of 0. I also created a similar interval variable to show injuries and fatalities by alcohol-related motor vehicle crashes by underage drivers. The variable would only be greater than 0 if the driver was underage *and* found to have an illegal BAC. The later variable will serve to answer my second research question. To perform my last preparation before analysis, I had to execute my second aggregation of the data from crashes to months. The resulting final data summed crashes per month for

the seventeen years, and limited now just to the State of Connecticut, included

information about injuries, fatalities, and how many occurred when the driver was

drinking and/ or underage (n= 204; 22 variables).

3.6 Statistical Analysis

With the final data set derived from the FARS data files, I could begin my

statistical analysis. To account for the time-series data I ran the models using the auto-

regressive integrated moving average (ARIMA) time-series procedure. This model will

help describe the behavior of crashes over time. The specific models that will be

estimated are:

(1) $Y_{t1} = \beta_0 + \beta_1 * Tax_t + \beta_2 * X_{t1}$

(2) $Y_{t2} = \beta_3 + \beta_4 * Tax_t + \beta_5 * X_{t2}$

The first model will serve to answer my first research question. Y_{t1} represents combined

morbidities and fatalities by alcohol-related motor vehicle crashes for month t. Tax_t

represents the excise tax, whose value will only be activated (i.e. $Tax_t=1$) in the months

including and after the tax excise increase (July 2011 and after). X_{t1} represents the

number of non-alcohol-related crashes that occurred in month t. This variable will control

the model for the trend of overall crashes that would have been present regardless of

alcohol use. For example, if the Connecticut's road conditions improve, this would affect

not just alcohol-related motor vehicle crashes but all crashes; X_{t1} will allow the model to account for unmeasurable qualities such as this.

The second model's equation will answer the second research question. Its variables limit the model particularly to crashes with underage drivers. Specifically, Y_{t2} represents morbidities and fatalities by alcohol-related motor vehicle crashes with an underage driver for month t. X_{t2} represents the number of non-alcohol-related crashes with an underage driver that occurred in month t. The inclusion of variables X_{t1} and X_{t2} was informed by the statistical analysis of crashes performed by Waagener et al., 2015, in which they used similar variables to control for trends of crashes unrelated to alcohol use.

To estimate and describe the two models, non-regression based *t* tests will be conducted using SAS version 9.4 for the difference in means of the pre- and post-tax injuries and fatalities for descriptive statistics and for validation of the ARIMA results. For the full-controlled results and sensitivity analyses, I will use STATA software version 15.1. Diagnostic tests of autocorrelation and unit-roots, typical of time-series data, will be conducted to inform the final models. The ARIMA will be used for both models in the same form of (0,0,0) (Nau, 2014); additionally, seasonality will be controlled for within the model through X_{t1} and X_{t2}.

Chapter 4

## RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Descriptive analysis of monthly alcohol-related motor vehicle crashes shows how injuries and mortalities fell from before to after the July 2011 excise tax increase in Connecticut. In the 138 months before the tax increase, the mean injuries and mortalities was 11.4 per month; in the 66 months including and after tax increase, the mean injuries and mortalities was 9.4 per month. Table 4.1 also shows the difference of the two means is 2.0 injuries and fatalities a month, with a t statistic of 2.48 corresponding to a p value of 0.014. The test on the difference of the two time periods concludes that monthly injuries and fatalities from alcohol-related motor vehicle crashes fell by a statistically significant and substantial amount. Figure 4.1 scatters the data on monthly injuries and fatalities from alcohol-related motor vehicle crashes and the grey line shows the negative trend from 2000 through 2016.

Table 4.1:   Monthly Injuries and Fatalities from Alcohol-Related Motor Vehicle
              Crashes

	Pre-increase	Post-increase	**Difference**
Mean	11.4	9.4	**2.0***
(Standard Error)	(0.48)	(0.63)	**(0.81)**
N	138	66	-

* p < 0.05, ** p < 0.01

Figure 4.1:   Monthly Injuries and Fatalities from Alcohol-Related Motor Vehicle
               Crashes
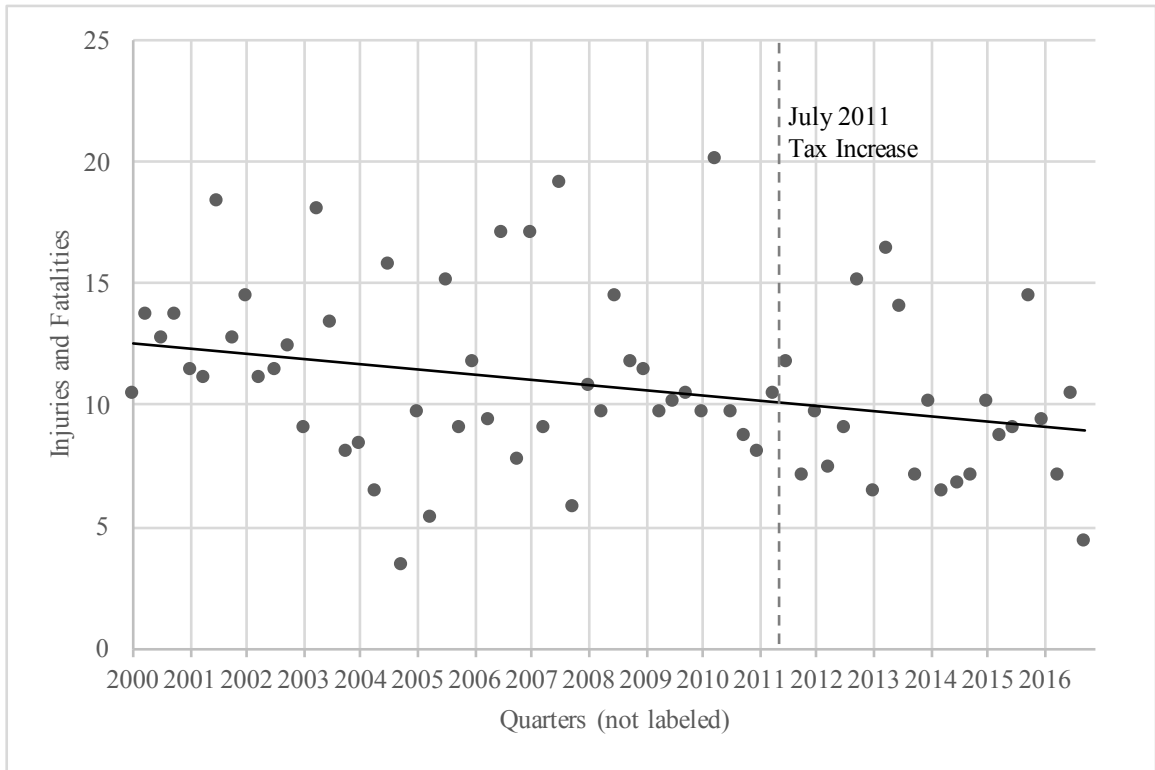
The bivariate analysis of injuries and fatalities from alcohol-related motor vehicle

crashes of underage (under 21 years of age) drivers shows a similarly significant decrease

from before to after the excise tax increase. Table 4.2 shows the mean injuries and

fatalities in both time periods; as shown, in this data the mean difference between the two

time periods of 1.1 injuries and fatalities a month is statistically significant with a t

statistic of 3.37 with a p value of 0.0009. Figure 4.2 scatters the data on monthly injuries

and fatalities from alcohol-related motor vehicle crashes of underage drivers; again, the

grey line shows the decreasing trend of monthly injuries and fatalities from alcohol-

related motor vehicle crashes of underage drivers.

Table 4.2:   Monthly Injuries and Fatalities from Alcohol-Related Motor Vehicle
              Crashes of Underage Drivers

	Pre-increase	Post-increase	**Difference**
Mean	1.8	0.7	**1.1****
(Standard Error)	(0.21)	(0.18)	**(0.33)**
N	138	66	**-**

* p < 0.05, ** p < 0.01

Figure 4.2:   Monthly Injuries and Fatalities from Alcohol-Related Motor Vehicle
              Crashes of Underage Drivers
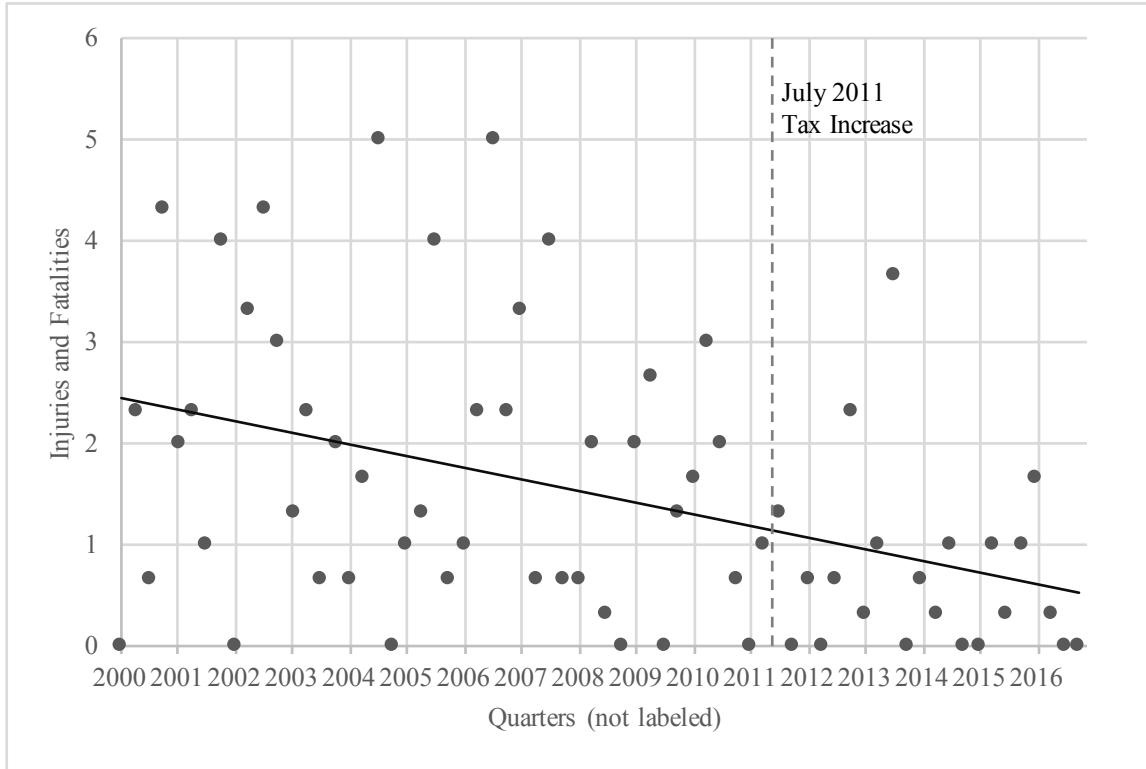
4.2   Regression Analysis

Time-series regression analysis allowed the data to be controlled for time and other variables that likely produced biased results in the *t* analysis. A multivariate ARIMA procedure on the dependent variable of injuries and fatalities per month was used to control for these previously confounding variables. The model generated for all ages of drivers is presented in Table 4.3.

Table 4.3:   Model One Results

Variable	Tax$_t$	X$_{t1}$	Constant (β_0)
Coefficient	-1.8*	0.2**	7.2**
(Standard Error)	(0.78)	(0.07)	(1.34)

* p < 0.05, ** p < 0.01

In the months in which the tax was implemented, the monthly injuries and
fatalities from alcohol-related motor vehicle crashes were 1.8 lower than in months
before the tax increase. The model shows a significant association of the tax increase on
injuries and fatalities per month. The control variable of non-drunk driving crashes was
also found to be statistically significant with a positive coefficient.

To address the second age-restricted model with a different dependent variable of
injuries and fatalities by underage drivers, the ARIMA model was again used using the
same structure as Model One. Table 4.4 presents the results of Model Two.

Table 4.4:   Model Two Results

Variable	Tax$_t$	X$_{t2}$	Constant (β_3)
Coefficient	-0.8**	0.2**	1.0**
(Standard Error)	(0.27)	(0.08)	(0.31)

* p < 0.05, ** p < 0.01

In the months in which the tax increase was implemented, the monthly injuries
and fatalities from alcohol-related motor vehicle crashes were 0.8 lower than in months

before the tax increase. In this age-restricted model, the effect of the policy was statistically significant. Another important result to note is that the constant term (β_3) of 1.0 compared to the higher constant term of the first model (β_0= 7.2) shows the much lower monthly injuries and fatalities in the age-restricted model. The difference can also be seen in Tables 4.1 and 4.2, which also show the reduced deviation in the age-restricted data. In Model Two, as for Model One, the control variable was found to be statistically significant with a very similar coefficient.

Both models were tested for autocorrelation in the error terms through the Durbin-Watson test and for non-stationary trends through the Dickey-Fuller unit root test. The linear regression of Model One returned a Durbin-Watson test statistic of 1.96. Considering an upper critical value of the Durbin-Watson statistic of 1.79 (Sanford, n.d.), I rejected the test's null hypothesis in favor of no autocorrelation (Studenmund, 2016). To diagnosis the appropriate autoregressive lag of the ARIMA model, iterations of the model with different lags informed the Bayes information criterion calculation, which validated the use of the autoregressive lag of 0. The test-statistic for the Dickey-Fuller test for unit roots suggested rejecting the null hypothesis in favor of no-unit root in the dependent variable (p= 0.000). These tests validated the use of the ARIMA model of (0,0,0) (Stock and Watson, 2011: 543), which controlled for a 0-autoregressive lag with a stationary dependent variable (Duke, n.d.). The Durbin-Watson test favored no autocorrelation (dw= 2.07) again in the second model, and because the second model's data was only a subset of all-aged drivers, I used the same ARIMA model form of (0,0,0).

4.3   Discussion

The excise tax increase on alcohol in Connecticut in July 2011 was associated with a decrease in monthly injuries and fatalities on the road. The tax policy intervention examined in this study was a 20 percent increase of the excise taxes of all types of alcohol. This research sought to find an association among the tax increase and health outcomes related to alcohol use. For all drivers with a blood alcohol content (BAC) over the legal limit, the monthly injuries and fatalities per month fell by 1.8 after the implementation of the tax increase, which was statistically significant. This result favored my hypothesis that health harms would fall as a result of the tax.

The Sheffield Alcohol Policy Model (SAPM) forecasts the effects of alcohol taxation on a wide-range of health outcomes. In fact, road traffic accidents is just one of 47 different health conditions included in the model (Brennan et al., 2008b: 71). The SAPM gives its results based on groupings of health outcomes, rather by individual outcomes. In addition, the SAPM looked at changes to health outcomes not just in the first year of tax implementation but at the policy's full effect (Brennan et al., 2008b: 126). In attempting to simulate as closely as possible the SAPM, my study estimated, rather than forecasted, what effect a tax increase had on a single health condition.

The data on health harms of alcohol-related motor vehicle crashes of all drivers show that injuries and fatalities were already falling in Connecticut, but that the tax contributed to that trend. In the model that focused on monthly injuries and fatalities from underage drivers, the tax increase was associated with a more significant impact. After the tax increase, the monthly injuries and fatalities from underage drivers were found to

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fall by 0.8, with respect to pre-implementation. The reduction was statistically significant; and considering that the counts of harms were much lower in the underage model compared to the all age driver model, the ratio of the reduction of harms attributable to the tax was greater.

This result coincides with my hypothesis that there would be more substantial harm reductions in younger drivers than for all drivers related to the alcohol tax increase. The higher ratio of the coefficient in the second model to the mean of the injuries and fatalities in the pre-tax increase period (0.8 to 1.8 or 44.4 percent) compared to the first model (1.8 to 11.4 or 15.7 percent) demonstrates that the reduction was more drastic. Alcohol can be already difficult to obtain for underage people as its consumption is illegal. A higher tax would act as an additional obstacle by increasing the price of alcohol. Consumers would feel different burdens of the same tax amount based on their incomes. Younger people with a lower income would have been more affected by the Connecticut tax increase. This could be an explanation for the more drastic impact of the tax increase in Model Two. The Sheffield Alcohol Policy Model also highlights the effects of taxes on subgroup populations. They estimate that in many tax policy scenarios the effects in underage drinkers will be more drastic than for the entire population (Brennan et al., 2008b). My study's results also agree with the body of literature that attribute a greater response to prices and taxes in younger-aged consumers.

This study contributes to the current available research on the effects of alcohol taxation. Through the evaluation of motor vehicle accidents in Connecticut this study supports the intervention to outcome pathway identified in the Sheffield Alcohol Policy

Model. Although this study omits the components of alcohol consumption, which is included in the SAPM, my model correctly assumes that the harm on the road is related to alcohol use. As alcohol-related accidents are classified by the FARS database through BAC levels, we can be certain that the driver did consume some type of alcohol. The use of the Connecticut tax increase as the policy intervention was ideal for study, the first of which to my knowledge to look at the State of Connecticut. Because the 2011 policy levied a 20 percent increase on excise taxes on all types of alcohol, the changes in harms do not need to be attributed to different types of alcohol, but to the one consistent alcohol tax increase. Another advantage of this study is that it focused on all harms on the road, including injuries and fatalities. Although the studies identified in my review of the literature separated injuries from fatalities, my study more closely followed the Sheffield Alcohol Policy Model in grouping all injury severities related to road traffic accidents.

4.4   Validity and Limitations

The internal validity of this study has been diagnosed and checked through sensitivity analyses. The model's diagnostic-verified statistical controls assert the certainty we can have with the results. Since the excise tax policy only influenced alcohol, the independent variables of control (X_{t1} and X_{t2}) from both models, which represent non-drunk driver accidents, form variables similar to control groups. Their inclusion allowed the models to control for what might have affected all crashes in Connecticut during the same time period, such as seasonal trends or road conditions. Both of these control variables in Models One and Two were both significant estimators

of their dependent variables (both with a p value of less than .003). Their significance

confirms that the variable was important to include as control. These variables decreased

the bias on the alcohol tax policy variable resulting in stronger results.

The certainty of the output is confirmed through other tests and regressions. Both

the non-restricted and age-restricted models had similar significance results in both the

difference of means and the ARIMA time-series analyses. In particular, Model One's t

statistic attributed a p value of 0.014 to the tax increase while the ARIMA model, with its

controls, attributed a p value of 0.021 to the tax increase. Both results were statistically

significant to the 95 confidence level. In Model Two the t statistic returned a p value of

0.0009 while the ARIMA model returned a p value of 0.003; both of which were

statistically significant to the 99 percent confidence level. Although the results of the

ARIMA models are a more robust output, the similar conclusions about the tax increase

in the t tests help to confirm the final results.

To confirm the sensitivity of the ARIMA models' results, I ran a series of models

using the State of Massachusetts as a control environment. During the study period of

2000 to 2016, Massachusetts had no change to its alcohol excise taxes (Distilled Spirits

Council, 2015: 25). Firstly, I re-ran the models replacing X_{t1} and X_{t2} with Massachusetts

data; that is, replaced them with non-drinking driver crashes in Massachusetts to control

for changes that would have affected driving conditions in the region. In both restructured

ARIMA models the alcohol tax increase variable retained nearly identical significances

as the Connecticut-only model (both significant to the 95 percent confidence level). The

analysis verified that the model's results on the tax increase were not due to factors

affecting the geographical area that would have caused bias in the Connecticut-only models.

Another model to check the results was run simulating the Connecticut excise tax in Massachusetts. That is to say, from July 2011 a variable for a tax increase was applied to monthly Massachusetts data in the same way as for Connecticut. The replanted tax increase variable had no significant impact on injuries and fatalities in Massachusetts, which was expected since the tax-law only affected Connecticut. The fabricated model shows that the results that the association of Connecticut's fatalities and injuries from drunk driving and the tax increase were not due to randomness. The final model used a panel data analysis with just Connecticut and Massachusetts to generate a difference-in-difference estimator. The average change in the outcome of injuries and fatalities per month was -1.54, negative just like the Connecticut ARIMA results, but with a p value of 0.135. The rigorous difference-and-difference estimator still shows a negative effect of the tax increase but its lack of significance may be due to a low statistical powered panel of only two states. Additionally, the difference-in-difference model assumes that Massachusetts was completely similar to Connecticut except for the tax increase, which is unlikely; therefore, its estimator is not reported among the major findings. Nevertheless, its inclusion is important to confirm the direction of the results.

In terms of external validity, the study limitations should be considered. Even though the study tried to simulate a natural experiment, the restrictions of the data eliminated the potential of complete randomness. As noted before, the FARS database only reports information about crashes that involved fatalities (NHTSA, 2017). This

means that crashes that just resulted in injuries, without any fatalities, could not be counted in my data analysis. In effect, I predict that the data may be severely under-counting the amount of injuries from alcohol-related crashes and the total non-alcohol related crashes, both dependent and independent variables. The reporting bias in the data should be considered in future studies, whereas the studies that I have found to use the FARS data have failed to note the limitation. Another weakness that might affect the implication of my study elsewhere might well be the study area. Connecticut, although chosen in a systematic fashion, may not be similar to other U.S. states or the entire country as a whole. As has been noted in other studies, state-wide taxes can be easily avoided in counties surrounding states without the tax policy (McClelland and Iselin, 2017). I assumed in my study that all the drinking drivers bought their alcohol under the new tax policy in Connecticut but it is possible that consumers may have made intentional choices to buy alcohol across the state border. Due to the small size of Connecticut, in comparison to other studies on larger states of Maryland and Illinois, this could have widely affected peoples' choices of where to buy alcohol. In addition, the drinking drivers that crashed on Connecticut roads may have just been driving through Connecticut, without having ever faced the state's increased tax. All of these conditions are valuable to consider when thinking how my results can and should be applied outside of Connecticut. Of course, the ideal study would have been like the Sheffield Alcohol Policy Model (SAPM) that estimated the effects over the entire country, but with a lack of federal policy regarding alcohol taxes, the State of Connecticut was a feasible and adaptable option.

In attempting to fully replicate the framework of the SAPM, this study also had notable limitations. Firstly, the components of the SAPM use a function of consumption as an intermediary step among the intervention and harms. The mathematical step of consumption is essential for the SAPM but for my needs it was not necessary. Consumption data is collected from self-reported surveys which are likely less reliable sources than government-published data on crashes. The ability in my study to attribute alcohol consumption, by way of blood alcohol content (BAC) levels, to drivers obviated the necessity of the intermediary consumption calculation. Secondly, the SAPM concentrates on the minimum unit price. Although this would have been the ideal tax to evaluate, its apparent absence from American alcohol policy left the choosing of an alcohol tax mechanism to another resource. A supplementary SAPM paper concluded that the strength of the volumetric tax to reduce health harms was high (Meier et al., 2016). For my study, this brought such a tax into favor after the minimum price. Another consideration, however, was that the tax increase in Connecticut was based on volume of total liquid, and would not be necessarily equivalent to alcoholic content as the SAPM model assumes. For example, even if two drinks of the same liquid content had different alcohol by volumes (ABV's) the tax would be equal for both drinks. In all, for the purpose of my study to look at the effects of taxation on health outcomes, these adaptations of the SAPM were necessary. However, if future studies and policy analyses wanted to examine specifically the minimum unit price and how it can affect health outcomes in the United States, such considerations would have to be made.

Chapter 5

CONCLUSION

The per-gallon excise tax increase in Connecticut in July 2011 was found in this study to be associated with a negative effect on the monthly number of combined injuries and fatalities from drunk driving traffic accidents. The tax increase also had a more drastic result on injuries and fatalities from drunk driving traffic accidents of underage drivers. Even after controlling for the monthly number of non-drunk driving accidents and intra-regional differences, the tax increase was still statistically significant. The association of the 20 percent excise tax increase in Connecticut to lower injury was a similar result found in some, but not all, of the literature on alcohol taxes found in the literature review. The Sheffield Alcohol Policy Model's (SAPM's) theoretical framework supports the decrease in injury from public policies to limit alcohol consumption.

This study reinforces the problem that alcohol consumption has consequences on health, work and other harms such as crime. Public policy should seek to intervene in the problem and the results presented in this thesis support the efficacy of an alcohol excise tax to limit the availability, consumption and ultimately health harms attributed to alcohol. The SAPM, unlike my study, focuses on the minimum unit price, which would set a price floor to each unit of alcohol. The minimum unit price has the advantage of only affecting the price of the cheapest alcohol, but not changing the price of more expensive alcohols. The volumetric tax, which is based on alcohol content, would be another tax policy for consideration. Other identified tax instruments include general taxes, or sales taxes, and ad valorem taxes. My study looks at a comparable option to the

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volumetric tax, but the excise tax in Connecticut was based on liquid content and not just alcohol content. Since public policy would be interested in reducing the effects of alcohol, it should address strictly the availability of ethanol. A tax based on alcohol by volume (ABV), for example, would be more similar to the minimum unit price or the volumetric tax, which implement price restrictions by unit of ethanol. In addition to the style of taxation, an essential consideration of any tax policy should be its revenue. A common theme providing the argument against taxes is the additional revenue for the general fund of governments. To this I suggest that policy makers put their priorities first on consequences of alcohol use rather than on the budgetary needs of the government. Ideally, revenue should be earmarked towards policy to further reduce the effects of alcohol use, ultimately benefitting all of society.

The research on the effects of different taxation is widely available, as shown by my review of the literature, my results and principally the forecasting estimates of the Sheffield Alcohol Policy Model. Attention to these evidence-based resources should be given when considering future policy. It is my hope that with my study, and the attention to policies of alcohol taxation, policy makers can realize the importance to creating well-designed taxes to benefit population health.

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