Effects of Tax Policy on Alcohol Consumption: Insights from the Connecticut Tax Increase of 2011

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Abstract

This paper investigates the effects of the state of Connecticut's 20 percent increase in alcohol taxes in 2011 on the alcohol consumption and health outcomes of state residents. Employing difference-in-difference models and the synthetic control method, we estimate a reduction of approximately 10 glasses per capita annually in wine consumption, while beer and spirits exhibit stable consumption patterns and low tax-elasticity. No significant changes are observed across age groups. Furthermore, health outcomes, including binge drinking prevalence, poor/fair health, chlamydia rate, and premature death, show no discernible changes.

Keywords: Tax Policy, Alcohol consumption, Health outcomes, Synthetic Control.

1. Introduction

Alcohol consumption and its associated health outcomes represent a significant societal concern, with profound implications for public health and economic well-being (WHO, 2001). In the United States alone, alcohol-related issues account for staggering figures: an estimated $249 billion in economic costs annually, equating to approximately $2.05 per drink consumed (Bouchery et al., 2011). Moreover, alcohol-related deaths reach a staggering 88,000 per year, an equivalent to the annual number of overall deaths in Austria in 2019 (NIAAA, 2020). Among young adults, the prevalence of excessive drinking poses a particular public health challenge, with a myriad of associated risks ranging from academic setbacks to serious health consequences (White, 2014). Heavy alcohol consumption is recognized as a significant global public health concern (Rehm et al., 2006), contributing to a range of conditions including liver diseases, cardiovascular problems, mental health disorders, cancer, poor birth outcomes, accidents, and injuries (Nilsson, 2017; Saffer, 1997; Dee, 1999).

Given the urgency of this issue, policymakers have long turned to taxation policies as a means to mitigate alcohol-related harms. Excise taxes, in particular, have been instrumental in shaping consumer behavior by influencing the price of alcoholic beverages (Cook & Moore, 1999). Research indicates an inverse relationship between alcohol prices and consumption (Gehrsitz, 2021). Therefore, by increasing excise tax rates, governments tend to stimulate a tax-induced increase in prices, eventually leading to a decrease in alcohol consumption. Consequently, understanding the impact of tax policies on alcohol demand across various demographic groups has become increasingly pertinent for policymakers seeking evidence-based strategies to address alcohol-related issues.

This paper delves into the impact of a 20 percent increase in alcohol taxes enacted in Connecticut in 2011 on alcohol consumption and related health outcomes. Using difference-in-difference models and recent advancements in synthetic control methods, we analyze the impact of taxation on government revenue, consumer behavior, and public health outcomes. Our analysis sheds light on the efficacy of tax policies in addressing public health concerns and provides actionable insights for policymakers.

Most of the existing literature on alcohol taxation focuses on price elasticity (Gallet, 2007; Wagenaar, 2009). Indeed, taxes can significantly distort consumer behavior and alter purchasing decisions. Researchers have demonstrated that taxes on alcohol products often result in an overshift to consumers, burdening them with disproportionately higher prices as the tax is passed on (Conlon and Rao, 2016). This paper seeks to fill a gap by placing emphasis on tax elasticity. While price-elasticity provides valuable insights into consumer behavior in response to price changes, tax-elasticity offers a more direct and policy-relevant perspective for understanding the effectiveness of excise taxes in regulating alcohol consumption. By delving into the specific impact of tax rates on consumer behavior, this paper aims to provide actionable insights for policymakers tasked with addressing public health concerns associated with alcohol misuse.

Taxes are not the only instrument at the disposal of policymakers. Prohibiting alcohol promotions, increasing the minimum legal age, or implementing a minimum unit price are additional methods often used for decreasing alcohol consumption (Anderson et al. (2009). However, we argue that taxes remain one of the most effective strategies among all the instruments available to policymakers at the state level. By increasing taxes on these goods, governments aim to discourage their consumption while simultaneously generating revenue that can be allocated towards addressing the social costs associated with their use, such as healthcare or addiction treatment programs that show promising evidence of cost-effectiveness (Le, 2023).

Our analysis unfolds in several stages. First, we examine the immediate impact of the tax increase on government revenue, revealing a substantial rise of approximately 23.86% compared to preceding fiscal years. We then prove that this increase in Revenue is entirely attributable to the implemented tax increase. Since Connecticut 2011 Tax increase is an increase in specific excise taxes (based on beverage quantity) keeping ad valorem rates (based on beverage price) constant, an increase in quantity of alcohol sold would bias the causality between tax increase and revenue collection. Because of this, we demonstrate that the rise in tax rates, rather than increases in consumer demand, is the exclusive driver behind the surge in revenue collection. To prove this point, we conduct a statistical analysis comparing the quantity of alcohol taxed by Connecticut before and after the tax increase. Our findings reveal that there is no statistically significant change in the quantity of alcohol taxed following the tax hike. We conclude that the observed 23% increase in Alcohol Excise Tax revenue is entirely attributable to the implemented tax increase.

Second, we examine alcoholic beverage sales data and find nuanced effects of the tax increase on consumption patterns. By using a Difference-in-Difference (DiD) model and the synthetic control method (Abadie, 2010), we compare the alcohol sales in Connecticut, our treatment group, to those in a carefully selected group of control states. We find that while beer and spirit consumption remain relatively stable, a significant decrease in wine consumption of approximately 10 glasses per capita annually emerges immediately after the tax change. We connect this result to the literature, explaining that the price-elasticity for wine is the highest among all three beverages with -1.11 (Gallet, 2007). This finding underscores the importance of considering beverage-specific responses to tax policies and highlights the need for targeted interventions.

Finally, our analysis extends to the evaluation of health outcomes, where we find no statistically significant effects across key variables including binge drinking prevalence, overall health indicators, and disease rates. These results contribute to the ongoing discussion surrounding the effectiveness of tax policies in mitigating alcohol-related harms. These results align with existing literature, which suggests that binge drinkers and other health outcomes are generally not highly responsive to increased prices in the short run (Nelson, 2015).

Overall, this paper underscores a significant policy implication. The analysis of Connecticut's tax increase on alcohol reveals that the current structure of alcohol excise tax rates may not be optimally designed nationwide, as evidenced by the consistent patterns observed in alcohol consumption data. Indeed, despite tax adjustments, there are no significant distortions evident in drinking patterns. Therefore, this paper provides empirical support for policymakers considering alcohol tax increases. It demonstrates the potential to enhance tax revenue without significantly disrupting alcohol consumption patterns and therefore generating little excess burden.

Finally, this research is particularly relevant given the historical trend of declining taxes on alcohol over time, accentuating the need for a critical examination of their efficacy and impact on public health (Tax Policy Center, 2017). In light of these diminishing tax rates, our findings underscore the urgency of reevaluating and potentially recalibrating tax policies to ensure they align with contemporary public health priorities and economic imperatives.

The rest of the paper is structured as follows: Section 2 provides an overview of previous research on alcohol taxation and outlines the background of the Connecticut tax increase. Section 3 discusses the data sources used in the analysis. Section 4 describes the methodology employed in this paper, with results presented in Section 5. Section 6 discusses the implications for policymakers, and the paper concludes with future research directions in Section 7.

2. Background

2.1 Past Research

2.1.1 Alcohol consumption and taxation

The relationship between alcohol consumption and personal utility is complex and contentious. Some researchers have long been associating alcohol use with increased utility. The potential advantages of moderate alcohol use have been frequently discussed in relation to increased happiness and decreased anxiety (Park, 2004). Alcohol consumption would not only be correlated with increased quality of life, but with positive health outcomes too. Some studies suggest that consuming alcohol lightly is linked to a decreased risk of all-cause mortality and health outcomes such as type 2 diabetes mellitus or heart attacks (O'Keefe et al, 2018). However, alcohol use has been linked to a number of adverse health outcomes and massive economic cost for governmental entities. The World Health Organization (WHO) estimates that alcohol is responsible for 8% of male mortality and contributes to up to 14% of disability-adjusted life years attributed to risk factors in developed countries (WHO, 2001). Heavy alcohol consumption is recognized as one of the significant global public health concerns (Rehm et al., 2006), leading to liver diseases, cardiovascular problems, mental health disorders, cancer, poor birth outcomes (Nilsson, 2017), accidents and injuries (Saffer, 1997; Dee, 1999), fetal alcohol spectrum disorders (Carpenter, 2007), and alcohol dependence and addiction (Dawson, 2006). Alcohol consumption not only poses health risks for the individual drinker, but also has negative effects on the health and economic well-being of their family, friends, and the wider community (Markowitz et al., 2005). A number of researchers are engaged in addressing the ongoing debate. Griswold et al. (2018) have contested O'Keefe's findings, asserting that all-cause mortality, particularly cancer mortality, escalates with higher levels of alcohol consumption. Hence, they argue that even moderate alcohol intake poses problems. Although the debate persists, alcohol consumption ranks as the third leading preventable cause of death in the United States (McGinnis & Foege, 1993).

Additionally, researchers concur on the evident relationship between heavy binge drinking, negative health outcomes, and heightened economic burdens. Alcohol abuse costs the United States approximately $249 billion, or about $2.05 per drink. This results in 88,000 deaths annually. Per capita, excessive alcohol consumption in the U.S. results in an economic impact of around $746 per person, with approximately 77% of this cost attributed to binge drinking (Bouchery et al., 2011; NIAAA, 2010). The relationship between binge drinking and negative health outcomes is even stronger among young adults, as they are particularly vulnerable to the long-term effects of excessive alcohol consumption. Alcohol use among young adults often is associated with a wide variety of risky behaviors and both immediate and long-term negative consequences (Chen et al., 2004). Consequences of college drinking include missed classes and lower grades, injuries, sexual assaults, overdoses, memory blackouts, changes in brain function, lingering cognitive deficits, and death as revealed by the widely cited article by White (2014). Despite generally consuming less alcohol on average per day compared to their non college peers, college students continue to stand out from other young adults due to their relatively high rates of heavy drinking (Johnston et al., 2004). For those reasons, the high prevalence of drinking among young adults poses a significant public health issue. This is particularly important for the United States, since throughout their lives, Americans typically exhibit the highest levels of alcohol consumption during their late teens and early twenties (Naimi et al., 2003; Fillmore et al., 1991).

Tax policies, particularly excise taxes, have been widely used by governments in an attempt to control alcohol consumption. The inverse relationship between alcohol prices and demand, as summarized by Cook & Moore (1999), indicates that higher taxes lead to decreased consumption making such taxes an effective tool in regulating alcohol use. By increasing excise tax rates, governments tend to stimulate a tax-induced increase in prices, eventually leading to a decrease in alcohol consumption. In this context, tax elasticity refers to the responsiveness of alcohol consumption to changes in alcohol taxes and price elasticity measures the responsiveness of quantity demanded to changes in price, regardless of the source of the price change. Most of the literature focuses on price elasticity, while only a few focus on tax elasticity. While price-elasticity provides valuable insights into consumer behavior in response to price changes, tax-elasticity offers a more comprehensive understanding by specifically accounting for the impact of tax policy interventions. Indeed, tax-elasticity analysis provides insights into how changes in tax rates directly affect consumption, offering policymakers a clear lever for intervention. Recognizing the importance of tax-elasticity in research is essential for informing evidence-based policy-making, especially with excise taxation on alcohol.

Research suggests that taxes are often over-shifted to consumers by a significant margin, with some studies indicating a factor of up to 1.5 (Gehrsitz, 2021). In other words, for every $1 increase in tax, the price for consumers may rise by as much as $1.50. Yet, taxes are not the sole instrument at the disposal of policymakers. Banning alcohol promotions, raising the minimum legal age, or setting a minimum unit price are also effective ways to reduce alcohol consumption, related health and social problems in a society (Anderson et al., 2009). However, taxes remain one of the most effective strategies. By increasing taxes on these goods, governments aim to discourage their consumption while simultaneously generating revenue that can be allocated towards addressing the social costs associated with their use, such as healthcare or addiction treatment programs. Understanding the impact of tax-induced price changes on alcohol demand across various demographic groups has grown in importance for policymakers. They seek evidence that pricing policies effectively target heavy or problem drinkers while avoiding disproportionate impacts on moderate drinkers. Research indicates that socioeconomically disadvantaged individuals and those prone to risky drinking are more likely to purchase inexpensive alcohol and suffer more alcohol-related harms compared to other segments of the population (Morrison et al., 2015; Callinan et al., 2015). According to the literature, individuals with lower incomes and those engaged in hazardous drinking also demonstrate greater responsiveness to price changes compared to higher-income individuals and moderate drinkers (Holmes et al., 2014; Meier et al., 2010). However, the impact of price changes on heavy drinkers remains contentious, with varying conclusions drawn from different reviews (Wagenaar et al., 2009; Nelson, 2013).

2.1.2 Non-causal experimental designs

Some researchers use non-causal experimental designs to address questions concerning the impact of policy measures on alcohol-related behaviors and outcomes. In their systematic review of 112 studies investigating the correlation between beverage alcohol tax or price levels and alcohol sales or self-reported drinking, Wagenaar et al. (2009) found that the mean elasticity estimates across the literature were −0.46 for beer, −0.69 for wine, and −0.80 for spirits. Similarly, Gallet (2007) conducted a meta-analysis of 132 studies employing a similar methodology. Gallet projected the price elasticity of beer to be –0.83, wine to be –1.11, and spirits to be –1.09. These findings from Gallet emphasized the importance of recognizing differences in price sensitivity across various types of alcoholic beverages and among different age groups of consumers. Indeed, understanding these nuances can inform more targeted and effective strategies, such as differential taxation or public health campaigns tailored to the preferences and behaviors of different segments of the population. This way, policymakers can enhance the impact of their efforts to promote healthier patterns of alcohol consumption. This paper endeavors to overcome the limitations inherent in the two meta-analyses mentioned above. First, it acknowledges the potential shortcomings of previous studies, which relied on price measures that may not be entirely reliable, often sourced from a limited selection of stores and alcoholic beverages. This approach could lead to inflated elasticity estimates, thus exaggerating the perceived effectiveness of alcohol taxes in reducing consumption (Ruhm et al., 2012). Additionally, some of these studies predominantly employed observational study designs, such as interrupted time series or simple panel models, which are susceptible to concerns regarding endogeneity, as elucidated by Gehrsitz (2021). To address these concerns, this paper adopts a novel approach. It leverages statewide sales data at the individual glass level to provide a more comprehensive assessment of alcohol consumption trends. By utilizing data at this granularity, the paper aims to mitigate the potential biases introduced by relying on limited store samples. Moreover, this paper supplements its analysis by comparing the obtained results with self-reported data, as in Ruhm and Black (2002). Indeed, self-reported data are widely regarded as one of the most reliable sources for tracking population health outcomes (Parrish, 2010). By incorporating this additional data source, this paper aims to enhance the robustness of the findings, providing a more nuanced understanding of the relationship between alcohol pricing and consumption behaviors.

Patra et al. (2012) conducted an examination of 36 taxation studies and 38 price studies focusing on high-risk drinking patterns or alcohol-related harms, encompassing alcohol dependency, alcohol-related hospitalizations, interpersonal violence, and various other consequences such as poisonings, drunk-driving incidents, and assaults. Their findings demonstrated an inverse relationship between alcohol price and consumption, indicating an elasticity of demand of -0.5. Specifically, a 10 percent rise in alcohol prices was associated with a 5 percent reduction in alcohol consumption, suggesting a moderate level of price responsiveness among consumers in the alcohol market compared to Wagenaar et al. (2009) and Gallet (2007). Nevertheless, despite these significant findings, there are notable limitations to consider. Variations exist among the studies in terms of their designs, settings, and the observed effects across different demographic groups and types of harm. These discrepancies result in inconsistencies in the overall conclusions drawn from the literature. This paper seeks to address these limitations through the adoption of the difference-in-difference model as a unique methodology. By employing this approach, this study aims to provide a more robust and nuanced analysis of the relationship between alcohol pricing and its impact on high-risk drinking patterns and alcohol-related harms. Through the careful application of this methodology, this paper endeavors to offer insights that overcome the inconsistencies observed in previous research, thus contributing to a more comprehensive understanding of the complex dynamics at play.

A 2010 review conducted by Elder et al. analyzes 22 econometric studies examining alcohol-related harms, predominantly within the United States, encompassing factors such as motor vehicle crashes, non-traffic mortality, violence, and alcohol dependence. Across the majority of the reviewed studies, they observed that estimates of price elasticity predominantly fell within the range of approximately 0.30 to 1.00. This suggests that a 10% increase in alcohol prices would typically result in a 3% to 10% decrease in alcohol consumption. However, the review identified several notable limitations. Firstly, there is a gap in understanding whether changes in alcohol prices have differential effects on drinking behavior and health outcomes among crucial subgroups of the population, notably young adults. Additionally, there is a lack of research elucidating the comparative benefits of uniformly increasing taxes on all alcoholic beverages versus selectively targeting specific beverage types. Moreover, it is essential to note that none of the meta-studies examined were associated with distinct major changes in alcohol policies; rather, their findings were influenced by other economic shifts, such as marginal variations in state excise taxes or gradual erosion over time in inflation-adjusted real taxes or real prices. To address these shortcomings, this paper proposes a different approach. Firstly, it focuses on the natural experiment in Connecticut, where taxes on three alcoholic beverages were increased simultaneously by 20%, in 2011. This allows for a more comprehensive examination of the impact of simultaneous tax hikes on alcohol consumption behavior. Secondly, this paper aims to segment the population by age group, facilitating a comparative analysis of the effects of tax rate increases on different demographic cohorts. By adopting these strategies, this study aims to provide insights that address the identified gaps in the literature, contributing to a more nuanced understanding of the complex relationship between alcohol pricing policies, consumption patterns, and public health outcomes.

2.1.3 Causal experimental designs

Researchers can use natural experiments to address the shortcomings of non-causal experimental designs. In alcohol policy research, a significant challenge arises from the bidirectional nature of causality, where effects can emanate both from policy implementations to outcomes and from outcomes back to policy decisions. For instance, econometric studies on behavioral effects of alcohol taxation encounter limitations due to the potential endogeneity of tax rates, which may be influenced by alcohol-related harms or other economic and political factors, rather than being determined solely by policy adjustments (Kubik el al, 2003; French et al, 2011). Moreover, as emphasized by Babor et al. (2010), the most compelling evidence regarding the impacts of alcohol policies emerges from examining the effects of interventions when they are introduced or removed, contrasting with periods or locations where no changes in the intervention occur. In other words, studying natural experiments appears to be an essential avenue for disentangling the dynamics of policy effects in curbing excessive alcohol consumption. Past assessments of alcohol-related harms have notably lacked extensive inclusion of natural experiments concerning price or tax policies (Nelson, 2016). For example, Patra et al. (2012) considered only four natural experiments in their analysis, while the extensively referenced study by Wagenaar (2009) comprised only three quasi-experimental design studies for Finland and one study for Switzerland. In other words, among the 186 studies examined by the two researchers, less than 5% employed causal experimental design analysis based on natural experiments.

Only a few studies attempt to draw conclusions from quasi-experiments environments. First, Nelson's meta-study (2016) presents an examination of natural experiments, encompassing 45 studies across nine countries: Australia, Denmark, Finland, Hong Kong, Iceland, Russia, Sweden, Switzerland, and the United States. Nelson's paper focuses on the impact of changes in alcohol prices on alcohol-related harms, providing a review of findings. His work uncovers a mix of results, indicating that alterations in taxes and prices exert selective effects on harms. Specifically, positive mortality outcomes are noted for liver disease and older individuals, particularly in Finland and Russia. Nevertheless, the study overlooks the assessment of the tax's impact on government revenue, a crucial consideration when studying sin taxes. Indeed, the revenue generated can be pivotal for investment in prevention and treatment initiatives, as explained above. Furthermore, the study focuses only on price elasticity, neglecting tax elasticity. It poses a significant limitation, as it fails to capture the full scope of policy impacts. Additionally, the inclusion of studies spanning lengthy time periods raises concerns about confounding factors, as noted by Nelson (2016). Moreover, weaker methodologies employed in some studies included in the research, coupled with small sample sizes in certain instances, compromise the statistical power of analyses.

In light of these limitations, this paper endeavors to rectify these shortcomings by incorporating a government revenue analysis into the study. This addition allows for a more comprehensive understanding of the broader fiscal implications of alcohol taxation policies. Moreover, the focus will solely be on tax elasticity, providing a clearer picture of the direct impact of tax changes on consumption behaviors. Additionally, this paper aims to differentiate between various subpopulations, thereby elucidating differential effects across demographic groups. By addressing these deficiencies, this study seeks to enhance the robustness and applicability of findings, ultimately contributing to more informed policymaking.

Gehrsitz's analysis (2021) constitutes the second contemporary approach to leverage a natural experiment to study the effect of changes in alcohol tax differentials on alcohol consumption. He leverages extensive retail scanner data from thousands of stores throughout the United States to create price metrics derived from a representative selection of products, ensuring consistency across time periods. Drawing insights from Illinois sharp and unexpected increase in excise tax on spirits and wine in 2009, the study reveals that individuals responded by adjusting their purchasing behaviors, with noticeable shifts observed in sales patterns across different alcohol categories. Specifically, the higher tax rates on spirits and wine led to increased prices for these beverages, prompting consumers to seek alternatives, such as beer, which remained unaffected by the tax hike. Consequently, while sales of spirits and wine declined, there was a corresponding increase in beer sales, mitigating the overall reduction in alcohol consumption. We replicate this main finding in Appendix B. Gehrsitz's paper presents some shortcomings. Firstly, the analysis overlooks the impact of uniform tax increases across all three alcoholic beverage categories. Given that only taxes on spirits and wine experienced significant hikes while beer taxes remained stagnant, Gehrsitz's study may not fully capture the complex dynamics of cross-product substitution, complicating the assessment of the overall effect on alcohol consumption. Second, Gehrsitz's study fails to address the implications of more modest tax increases, which are often more feasible for states to implement. The substantial doubling of excise taxes on spirits - from \$4.50 to \$8.55 per gallon - and wine - from \$0.73 to \$1.39 per gallon - in the study's experimental setting may not accurately reflect the incremental tax adjustments that states are more likely to enact in practice.

To address these gaps, this paper adopts a different approach. We focus on a moderate 20% increase in tax rates, aiming to provide insights into the potential effects of more realistic tax policy changes. By doing so, this paper aims to offer a more practical perspective on the impact of alcohol taxation on consumption behaviors. Furthermore, this paper goes beyond Gehrsitz's analysis by segmenting the population to examine the specific impact of tax changes on young people's alcohol consumption. This segmentation allows us to complement Gehrsitz's findings and provide a more comprehensive understanding of how different demographic groups, particularly young adults, respond to changes in alcohol taxation.

2.2 Background of the 2011 Connecticut Tax Increase

Alcohol taxation in the United States is primarily governed by federal and state regulations, with varying rates applied to beer, wine, and distilled spirits. Each state imposes two primary types of taxes: "specific excise taxes" based on beverage quantity and the "ad valorem excise taxes" based on beverage price. Since the 1950s, there has been a notable decline in the real value of both state and federal alcohol taxes (Wagenaar, 2010). Consequently, this diminishing value of alcohol taxes has resulted in a substantial reduction in the inflation-adjusted price of alcohol. Furthermore, this decline in price reflects the effective translation of tax modifications into price alterations within the alcohol market (Elder, 2010). In late April 2011, the Finance Revenue and Bonding Committee of the Connecticut General Assembly approved a proposal to increase the state's specific excise taxes on all three categories of alcoholic beverages by 20%, maintaining ad valorem taxes constant.

This initiative aimed to address the negative health and public safety externalities associated with alcohol consumption (Conlon and Rao, 2016). The implementation of this measure was anticipated to generate approximately $9.8 million in revenue during the first year and $9.3 million in the second year. These revised tax rates applied to sales conducted by licensed distributors on or after July 1, 2011. Table 4 describes the evolution of Connecticut alcohol tax rates over time. Still Wines, not exceeding 21% alcohol by volume, saw an increase in tax rates from $0.60 to $0.72 per unit. For Beer and Other Malt Liquors sold in other containers, the tax rate rose from $0.19 to $0.24 per unit. Lastly, the tax rate for Distilled Liquors experienced an increase from $4.50 to $5.40 per unit.

This tax increase took the business community by surprise, eliciting strong reactions.

On April 23, 2011, a local newspaper headlined "Connecticut's 20 percent alcohol tax increase sparks outrage," capturing the concerns voiced by restaurants and the liquor industry. They expressed apprehension that the hike could drive more of the state's business northward or to neighboring states with more favorable tax policies (Middletown, 2011). The American Beverage Institute (ABI) echoed these sentiments, warning that the proposed increase could result in job losses and disproportionately impact those unable to absorb the higher tax burden (ABI, 2011).

Conlon and Rao (2016) examine the pass-through dynamics of alcohol taxes on distilled spirits prices using granular UPC-level data from Nielsen Homescan. Their findings revealed an over-shifting of the tax into both wholesale and retail prices within a one-month timeframe, with a wholesale rate of 1.302 and a retail rate of 1.533, aligning with established economic theories. Notably, the Cournot oligopoly model, articulated by Scherer and Ross (1990), posits that in industries marked by high concentration and low price elasticity, taxes tend to be disproportionately borne by consumers. Additionally, Conlon and Rao (2016) identified systematic variations in pass-through rates across different retail outlets. They observed that stores offering lower prices for a given product tended to pass on tax increases more significantly. For instance, in low-price stores, taxes were passed on at a rate averaging between 290-300%, whereas in high-price stores, the pass-through rate ranged only between 26-31%.

3. Data

We provide information on data sources in Table 1. In what follows, we discuss the data we used for our analysis in detail. First, we present the Tax Revenue Data from the State of Connecticut. Then, we describe our alcohol consumption data, including the alcohol sales dataset and self-reported consumption data. Finally, we present the survey measures of health outcomes.

3.1 Connecticut Revenue

To analyze the revenue generated by the State of Connecticut, we use public data from the Department of Revenue Services of the State of Connecticut, published monthly from

2003 to 2024. The report offers a comprehensive overview of tax revenue generated from different types of alcoholic beverages over specific time periods. It details information on malt beverages, wines (both under and over 21% alcohol), distilled liquor, liquor coolers, and alcohol. The report highlights the tax rates applied to each beverage category and provides data on the quantities sold and corresponding tax revenues. We use this data for an analysis of consumption patterns and revenue generation trends. Additionally, a revenue collection summary compares total revenue figures between consecutive fiscal years, illustrating any changes in overall revenue and providing insights into the state's alcohol taxation landscape.

3.2 Alcohol consumption

3.2.1 Alcoholic beverage sales data

Description of the dataset

To assess changes in alcohol consumption, we use state-level sales data sourced from the National Institute on Alcohol Abuse and Alcoholism (NIAAA) 34th surveillance report spanning 1977 to 2018, detailing per capita alcohol consumption in the United States (Slater and Alpert, 2020). These reports are published annually by the NIAAA. This dataset is based on alcoholic beverage sales data gathered by the Alcohol Epidemiologic Data System (AEDS) from state sources or the National Alcohol Beverage Control Association, along with industry reports (referenced in Table 1). AEDS employs an average ethanol content estimate to convert gallons of beer, wine, and spirits sold or shipped into gallons of pure ethanol, subsequently calculating per capita consumption rates using population data from the U.S. Census Bureau. After ethanol conversion, the report aggregates ethanol gallons from beer, wine, and spirits to provide an overall ethanol consumption figure. Additionally, the report outlines a standard drink estimation, aligning with NIAAA's definition (2010) of a standard drink in the United States as containing 0.6 fluid ounces of ethanol. This methodology allows for tracking changes in alcohol consumption patterns over time and understanding trends in alcohol use at a population level.

We provide strong evidence for a robustness check by replicating the seminal work of Gehrsitz (2021) using the NIAAA dataset. The replication analysis can be found in Appendix B.

Summary statistics

The table 2 presents the summary statistics for the Alcoholic Beverages data and for the control variables used in the analysis. Connecticut's per capita alcohol consumption for all beverages has experienced a notable decrease over the span of four decades (Figure 3), declining from 563 drinks per capita in 1977 to 512 drinks per capita in 2018 (-9%). This shift is primarily attributed to a significant drop in beer consumption, which fell from 251 drinks per capita in 1977 to 189 drinks per capita in 2018 (-25%), as reflected in Figure 4. Spirits consumption also displayed some fluctuations, particularly a sharp decrease in drinks consumption after Connecticut's increase in drinking age to 20 in 1983 and to 21 in 1985 (Figure 5). Meanwhile, wine consumption increased from 1977 to 2011 by 72%, with a decrease observed starting 2011 (Figure 6). These changes reflect a broader transition in drinking preferences, suggesting a potential inclination towards moderation or a shift towards alternative beverage choices within the state of Connecticut.

Per capita alcohol consumption for all beverages in the United States has followed a similar trend to that of Connecticut, with a notable decrease over the four-decade period from 1977 to 2018 (Figure 7). Starting at 555 drinks per capita in 1977, total alcohol consumption declined to 501 by 2018, representing a 10% decrease. This decline was primarily driven by a significant drop in beer consumption, which fell by 18% between 1977 and 2018 (Figure 8), and by spirits consumption, which decreased by 16% (Figure 9). In contrast, wine consumption increased by 52% over the same period (Figure 10).

3.2.2 Self-reported data on Alcohol consumption

Description of the dataset

To complement the Alcoholic beverage sales data, we incorporate self-reported data from surveys published by the Behavioral Risk Factor Surveillance System (BRFSS). Indeed, by comparing sales data with self-reported data, this paper aims to identify any discrepancies between actual consumption and reported consumption. This method follows the recommendations in Parrish (2010) that notes that self reported data are among the best sources of data to track population health outcomes.

The Behavioral Risk Factor Surveillance System (BRFSS) is administered by the CDC National Center for Chronic Disease Prevention and Health Promotion, and serves as a cornerstone of public health surveillance within the United States. It offers a comprehensive overview of various health-related behaviors, including alcohol consumption, among U.S. residents and published at the state level. Established in 1984 with participation from 15 states, BRFSS has since expanded its reach to encompass all 50 states, the District of Columbia, and three U.S. territories. This expansion has positioned BRFSS as the largest continuously conducted health survey system globally. Since 2011, this dataset has included over 400,000 annual respondents aged 18 and over, who own either landline telephones or cellphones.

Specifically, this paper uses the comprehensive data offered by the BRFSS Prevalence & Trends Data to examine changes in self-reported alcohol consumption. This survey focuses on the number of adults who reported having consumed at least one alcoholic drink within the preceding 30 days. This crude prevalence is categorized by age groups: 18-24, 25-34, 35-44, 45-54, 55-64, and 65+. This segmentation enables a nuanced exploration of the effects of tax increases on various demographic subgroups within the population.

Summary statistics

The table 3 presents the summary statistics for the BRFSS Data and for the control variables used in the analysis. In 2006, the majority of adults across all age groups reported having consumed at least one alcoholic drink within the past 30 days. Specifically, the highest prevalence was among individuals aged 35-44, with 67.5% reporting alcohol consumption, followed closely by those aged 45-54 (65.8%) and 55-64 (65.4%). Among younger adults aged 18-24, the prevalence was slightly lower but still substantial at 60.7%. Conversely, the lowest prevalence was among individuals aged 65 and older, with 53.5% reporting alcohol consumption.

In 2010, one year before the increase in tax, the prevalence of alcohol consumption among adults in Connecticut showed varying patterns. A majority of adults reported having consumed at least one alcoholic drink within the past 30 days. Notably, the highest prevalence was observed among individuals aged 25-34, with 76.1% reporting alcohol consumption, followed by those aged 35-44 (70.2%) and 45-54 (67.2%). The prevalence among younger adults aged 18-24 was also significant, with 61.8% reporting alcohol consumption. However, the prevalence decreased among older age groups, with 55.0% of individuals aged 65 and older reporting alcohol consumption.

The trend observed from 2006 to 2010 suggests some variations in alcohol consumption patterns among adults in Connecticut, particularly concerning different age groups. In 2006, a consistent trend was noted across all age groups, with a majority reporting alcohol consumption within the past 30 days. The highest prevalence was among individuals aged 35-44, closely followed by those aged 45-54 and 55-64, indicating a relatively stable pattern of alcohol consumption among middle-aged adults. However, in 2010, one year before the tax increase, we observed a shift in this pattern. While the prevalence remained high among younger adults aged 25-34, there was a notable increase in prevalence among this group compared to 2006. Additionally, the prevalence decreased among older age groups, suggesting a potential shift in drinking habits or behaviors among different demographic cohorts.

Comparing 2011 to 2010, the prevalence of alcohol consumption in Connecticut remained high across most age groups. While there was a slight decrease in prevalence among younger adults aged 18-24 (from 61.8% in 2010 to 57.3% in 2011), the prevalence among older adults aged 55-64 and 65+ increased slightly.

3.3 Health outcomes

Description of the dataset

Finally, we integrate health outcome data into our analysis to assess the impact of alcohol consumption on public health and evaluate the effectiveness of the tax increase in reducing harmful alcohol-related outcomes. To analyze health outcomes, we collect self-reported data on binge drinking, health status, and statistical estimates of premature death rate and chlamydia rate, as recommended by the literature (Parrish, 2010). All estimates are calculated at the county level from 2009 (earliest year available) to 2016, providing a 5-year range after the tax increase of 2011 for comparison. This paper includes in the analysis the counties of states Connecticut (CT), Maryland (MD), Maine (ME), Minnesota (MN) and New Hampshire (NH). The selection of these states was determined by the results of the synthetic control method for the alcohol consumption analysis. Specifically, the synthetic control group for Connecticut used weights derived from the four mentioned states to minimize differences in predictor variables during the pre-treatment period. Additionally, no changes in alcohol taxes for those four states were recorded during the period of the analysis.

One limitation to note for binge drinking[1] rates is that participants may have difficulty accurately recalling past instances of binge drinking, leading to inaccuracies in reporting. This can particularly affect binge drinking, which often involves heavy alcohol consumption in a short period, potentially impairing memory of the event (Ruhm and Black, 2002). To analyze health status, BRFSS provides the percentage of adults in a county who consider themselves to be in poor or fair health. Self-reported health status is a widely used measure of people's health-related quality of life (BRFSS, 2010).

We also report the premature death rate using data published from the National Center for Health Statistics (NCHS), calculated as the years of potential life lost before age 75 per 100,000 population (age-adjusted). Indeed, Years of Potential Life Lost serves as a commonly employed metric for assessing the rate and distribution of premature mortality. By quantifying premature mortality instead of overall mortality, this measure directs attention to deaths that could potentially have been avoided.

Finally, we analyze the change in chlamydia rate as the number of newly diagnosed chlamydia cases per 100,000 population. We collect the data from the National Center for Hepatitis, HIV, STD, and TB Prevention (NCHHSTP), administered by the Centers for Disease Control and Prevention (CDC). This analysis is relevant since the recent literature revealed an association between alcohol use, especially heavy drinking occasions, and STIs (Llamosas-Falcón 2023, Kabapy et al., 2020). Alcohol consumption has been

[1] BRFSS calculates binge drinking as the percentage of males having five or more drinks on one occasion or females having four or more drinks on one occasion.

linked to various forms of sexual risk behavior, including engaging in unprotected sex or having multiple sexual partners (George, 2019; Khadr et al., 2016). These behaviors are correlated with an increased risk of sexually transmitted infections (STIs).

Summary statistics

From 2010 to 2016, Connecticut has shown a relatively stable trend in binge drinking behavior. The percentage of individuals reporting binge drinking, defined as males having five or more drinks on one occasion or females having four or more drinks on one occasion, has fluctuated slightly, typically ranging between approximately 13.6% and 19.0%. Conversely, the percentage of individuals not reporting binge drinking has remained consistently high, generally between approximately 81.0% and 86.4%.

Likewise, Connecticut has exhibited a consistent trend in overall health status. The percentage of individuals reporting "Good or Better Health" has generally ranged between approximately 85% and 89%, with minor fluctuations over the years. Conversely, the percentage reporting "Fair or Poor Health" has remained relatively stable, typically fluctuating between approximately 11% and 15%. This suggests a consistent perception of health status among Connecticut residents over time.

The trend in premature death rates in Connecticut shows a gradual decline, with some fluctuations observed in certain years. In 2010, the average premature death rate stood at approximately 5,900 per 100,000 population. Over the following years, there was a consistent decrease in premature death rates, reaching a low point around 2015, where the average rate dropped to approximately 5,300 per 100,000 population. However, there was a slight increase in premature death rates in 2016, with the average rate rising back to around 5,500 per 100,000 population.

The trend in Chlamydia rates in Connecticut reveals significant variability among counties, with some experiencing relatively low rates while others show considerably higher rates. From 2010 to 2014, there is a discernible upward trajectory in Chlamydia rates across most counties, indicating an overall increase in newly diagnosed cases per 100,000 population. Around 2014, there is a peak in Chlamydia rates across many counties, signifying a potential period of heightened transmission or improved detection methods.

However, from 2014 to 2015, there is a slight decline observed in some counties, especially the ones with older populations.

4. Empirical methodology

We employ a classic Difference-in-Differences (DiD) approach and use the synthetic control method to estimate the effects of alcohol taxes on alcohol consumption and various health outcomes. This allows us to estimate the causal effect of the 2011 state increase in tax by comparing changes in outcomes over time between a treatment group and a control group, as in Gehrsitz (2021).

4.1 Alcoholic Beverage Sales

To gain insights into the impact of alcohol consumption on health outcomes, we first examine alcohol sales data. Per capita consumption of ethanol from different beverage types (beer, wine, and spirits) serves as our dependant variable to measure alcohol sales. By conducting a Difference-in-Differences (DiD) analysis, we compare the alcohol sales trends in Connecticut, our treatment group, to those in a carefully selected group of control states.

$$Y_{bst} = \alpha_0 + \alpha_1 D_s + \alpha_2 T_t + \alpha_3 (D_s * T_t) + \chi_s + \lambda_s + \lambda_t + \epsilon_{st} \tag{1}$$

Here, Y_{bst} represents the per capita consumption of ethanol from beverage type b (beer, wine, or spirits) for state s in time period t. D_s is a dummy variable equal to 1 if the observation is from the treatment group (Connecticut), T_t is a dummy variable equal to 1 if the observation is in the post-treatment period, and χ_s includes control variables specific to state s, such as age, income, marital status, education, and unemployment rate. State (λ_s) and time (λ_t) fixed effects are also included to account for any unobserved heterogeneity, and ϵ_{st} captures the error term.

4.2 Self-reported Alcohol Consumption

Building on the insights gained from the analysis of alcohol sales data, we further investigate the relationship between alcohol consumption and health outcomes. Specifically, we focus on self-reported alcohol consumption rates among adults from age group g who have consumed at least one drink of alcohol within the past 30 days. Using a similar DiD framework, we compare Connecticut to the same group of control states.

The regression equation for this analysis is as follows:

$$Y_{gst} = \beta_0 + \beta_1 D_s + \beta_2 T_t + \beta_3 (D_s * T_t) + \chi_s + \lambda_s + \lambda_t + \epsilon_{st} \tag{2}$$

Here, Y_{gst} represents the alcohol consumption rate for state s in time period t. D_s, T_t, χ_s, λ_s, λ_t, and ϵ_{st} are defined as in the previous equation.

4.3 Health Outcomes Analysis

Finally, we evaluate the impact of the tax increase on health outcomes by contrasting Connecticut counties (the treatment group) with those from other states (the control group), specifically from Maryland (MD), Maine (ME), Minnesota (MN), and New Hampshire (NH).

The regression equation for this analysis is as follows:

$$Y_{ct} = \gamma_0 + \gamma_1 D_c + \gamma_2 T_t + \gamma_3 (D_c * T_t) + \chi_c + \lambda_c + \lambda_t + \epsilon_{ct} \tag{3}$$

Here, Y_{ct} represents the health outcomes for county c in time period t, including the variables binge drinking prevalence (%), poor/fair health (%), chlamydia rate (Number of newly diagnosed chlamydia cases per 100,000 population), and premature death (Years of potential life lost before age 75 per 100,000 population, age adjusted). D_c and T_t are dummy variables indicating whether the observation is from the treatment group and in the post-treatment period, respectively.

The term χ_c includes control variables specific to county c: age, income, marital status, education, and unemployment rate. Additionally, state (λ_c) and time (λ_t) fixed effects are incorporated to control for unobserved heterogeneity, and ϵ_{ct} captures the error term, representing unobservable factors affecting changes in health outcomes over time.

4.4 Enhancing the DiD Analysis via Synthetic Control

To enhance our analysis, we use the "synthetic control" method developed by Abadie and Hainmueller (2010). This method generates a synthetic control group that closely mirrors the outcomes observed in the treatment group by leveraging a weighted combination of untreated units. Our control units are chosen based on pre-treatment characteristics and pre-intervention outcome data. By selecting a weighted combination of control units based on their pre-intervention outcome data, the synthetic control method attempts to ensure that the parallel trend assumption holds. Details regarding the implementation of the method in our study can be found in Appendix A, where we delineate the steps employed to execute this approach in the Appendix.

SCM operates by minimizing the discrepancy between the observed outcomes of the treated unit and the weighted sum of outcomes from the control units. Mathematically, let $\hat{\theta}_{jt}$ represent the vector of estimated weights assigned to control unit j at time t, and $\hat{Y}_{it}$ denote the predicted outcome for the treated unit Y_{it}. The objective function of SCM is formulated as follows:

$$\min_{\boldsymbol{\theta}} \sum_{t=1}^{T} \left(Y_{it} - \sum_{j=1}^{J} \theta_{jt} Y_{ijt} \right)^2$$

Subject to the two following constraints:

$$\sum_{j=1}^{J} \theta_{jt} = 1;$$

$$\theta_{jt} \geq 0.$$

The synthetic control construction allows us to compute the predicted outcome $\hat{Y}_{it}$ as a weighted sum of outcomes from the control units:

$$\hat{Y}_{it} = \sum_{j=1}^{J} \hat{\theta}_{jt} Y_{ijt}$$

In essence, SCM identifies a combination of control units and assigns weights to each such that the synthetic control closely resembles the treated unit's pre-treatment characteristics. This allows researchers to compare the actual outcome of the treated unit post-treatment with the synthetic control, thereby estimating the causal effect of the treatment.

5. Results

5.1 Government Revenue

Table 5 depicts the total alcohol tax revenue accrued over fiscal years in the state of Connecticut, along with the year-on-year changes in millions of dollars. Notably, there is a significant increase in revenue during Fiscal Year 2012 compared to preceding fiscal years. This surge in revenue aligns with the implementation of a 20% tax hike effective July 1, 2011, i.e the beginning of Fiscal Year 2012. Specifically, in Fiscal Year 2010, Connecticut's total revenue only increased by \$1.13 million compared to the previous year (+2.4%). Similarly, in Fiscal Year 2011, there was a minor increase of \$0.73 million (+1.5%). However, the most substantial increase occurred in Fiscal Year 2012, with an increase of \$11,67 million (+23.86%) in revenue compared to the previous year. Following this sharp increase, the revenue collected by the state of Connecticut stabilized at \$60 million per fiscal year.

The Figure 1 illustrates the revenue collected over the course of 12 months for three fiscal years: 2010, 2011, and 2012. Each fiscal year is represented by a separate line on the graph. Notably, the lines for 2010 and 2011, before the implementation of the tax increase, appear to overlap, indicating similar levels of revenue collection during those years. However, the line for Fiscal Year 2012, following the tax hike effective July 1, 2012, exhibits a noticeable shift upwards. Importantly, the shape of the line for 2012 remains consistent with the other years, reflecting similar seasonal patterns in government revenue collection and suggesting inelasticity (Picard, 1991). Moreover, the area between the curve for 2012 and the curve for 2011 represents the additional revenue generated as a result of the tax increase. This increase amounts to $11.67 million, indicating the direct impact of the tax hike on revenue generation. By maintaining the same seasonal pattern but shifting the entire curve upwards, the graph effectively illustrates how the tax hike led to a significant increase in revenue without altering the underlying trends in revenue collection throughout the year.

However, to properly attribute the increase in revenue collection during Fiscal Year 2012 to the implementation of the 20% tax hike effective July 1, 2012, we need to ensure that the quantity of alcohol taxed did not increase during that fiscal year compared to the previous year. Indeed, with the state of Connecticut increasing its specific excise taxes based on beverage quantity maintaining ad valorem taxes constant, an increase in revenue could be biased by higher volumes of taxed alcohol rather than solely the tax hike itself.

The graphs depicted in the Figures 2 present the change in the quantity of alcohol taxed by the state for Fiscal Year 2011 (prior to the tax increase) and Fiscal Year 2012 (following the tax increase) across three different alcoholic beverages. Each graph illustrates two lines, one representing the quantity taxed in Fiscal Year 2011 and the other representing the quantity taxed in Fiscal Year 2012. Visually, the two lines in each graph appear to overlap, suggesting no discernible change in the quantity of alcohol taxed between the two fiscal years. This visual observation is further supported by statistical analysis, specifically the t-test results displayed in Table 6.

The p-values in the table indicate the significance of the observed differences in the quantity of alcohol taxed between Fiscal Year 2011 and Fiscal Year 2012 for each beverage category. With p-values greater than 0.05 for all categories, we fail to reject the null hypothesis, suggesting that there is no statistically significant change in the quantity of alcohol taxed between the two fiscal years. This implies that despite the implementation of the tax increase in Fiscal Year 2012, there was no notable variation in the volume of alcohol subject to taxation across different beverage categories.

These pieces of evidence allow us to conclude that the 2011 tax increase resulted in an additional annual collection of \$11.67 million for the state of Connecticut, marking a surge of approximately 23.86% compared to Fiscal Year 2011. Therefore, the data suggests a clear and direct impact of the tax hike on revenue generation in the state of Connecticut, highlighting its effectiveness in boosting government income.

5.2 Alcohol consumption

5.2.1 Alcoholic Beverage Sales

We start by studying the impact of the tax increase on alcohol consumption by analyzing sales data of alcoholic beverages. To facilitate this analysis, we utilize the synthetic control method and construct a synthetic control group representing the counterfactual scenario of what alcohol consumption would have been in the absence of the tax hike. Our synthetic control comprises data from several states, including Alaska, Arkansas, Maryland, Utah, and Delaware, each weighted differently based on their similarities to Connecticut in terms of relevant socio-economic factors.

We begin by investigating the change in beer sales. Figure 11 illustrates the changes in the number of beer consumed per capita from 2000 to 2018. Upon visual inspection, the graph representing beer consumption reveals no conspicuous statistical changes and may even suggest a relative increase. This visual observation is further supported by the p-value, a statistical measure of significance, provided alongside Figure 7. Specifically, the analysis indicates that in the years subsequent to the tax hike, there is no discernible change in beer consumption patterns.

The results are consistent when examining spirit consumption. Indeed, the analysis of spirit consumption patterns using the synthetic control method and examining changes in per capita consumption over the same period does not reveal any statistically significant deviations following the implementation of the tax hike (Figure 12). The findings are reflected in Table 7, which presents the p-values for the analysis, and in the weights assigned to each state in the synthetic control model (Table A2 and A1). The lack of statistically significant changes in spirit consumption following the tax increase is indicative of the robustness of the results across different types of alcoholic beverages.

Interestingly, the analysis of wine consumption reveals a significant deviation, showing a decrease of approximately 7 glasses per capita immediately following the increase in taxes (year 2012 and 2013), and between 11 and 14 glasses per capita per year for the years after (Figure 13). This decrease is highly significant, with p-values significant at the 5% confidence level for 2012, 2013, and 2016, and significant at the 0.1% level for the other years (Table 7). This finding contrasts with the observations for beer and spirit consumption, suggesting that the tax increase may have had a distinct impact on various types of alcoholic beverages. This observation is supported by Gallet's (2007) meta-analysis of 132 studies, which found that the price-elasticity for wine is the highest among all three beverages (-1.11).

Remarkably, the synthetic control method demonstrates particular efficacy in analyzing wine sales, as evidenced by Figure 13. In the pre-period, both the control and treatment groups exhibit nearly perfect parallel trends, indicating minimal differences in predictor variables (Table A1). This suggests that the synthetic control method successfully mitigates potential confounding factors, ensuring a robust analysis of the impact of the tax increase on wine consumption. The statistical significance of these changes is assessed through hypothesis testing, where the null hypothesis states that there is no significant change in wine consumption compared to the previous year. Beginning in 2012, the p-values drop below the threshold of 0.05, indicating statistically significant changes in wine consumption for each subsequent year. Specifically, in 2012, 2013, 2014, and 2015, the p-values are 0.02, 0.02, 0.00, and 0.00, respectively, indicating significant deviations from the null hypothesis (Table 7). Overall, the estimates of changes and the associated p-values provide valuable insights into the changes in wine consumption over the years, down to more than 14 glasses per year per capita.

5.2.2 Self-reported Consumption

Following the implementation of a tax increase in 2011, we observe the fluctuations in alcohol prevalence across different age groups used as a proxy for alcohol consumption. However, despite these variations, statistical analysis indicates that there is no significant overall change in prevalence. While certain age demographics showed fluctuations in alcohol prevalence over the subsequent years, the associated p-values suggest that these changes were not statistically meaningful. Therefore, while the tax increase may have influenced consumption patterns to some extent, the data does not support the assertion of a significant overall change in alcohol consumption.

Table 8 and 9 provide insights into changes in alcohol prevalence among different age groups following an increase in alcohol tax in 2011. The tables present estimates and corresponding p-values for changes in alcohol prevalence compared to the previous year for various age demographics.

Following the tax increase in 2011, Table 8 illustrates fluctuations in alcohol prevalence among the age group of 18-44 years old. For instance, in 2012, there is a notable decrease in alcohol prevalence among 18-24-year-olds by 4.83 percentage points compared to 2011. However, this change is not statistically significant (p-value = 0.767). Similarly, in 2014, there is a decrease in alcohol prevalence among 25-34-year-olds by 7.29 percentage points compared to the previous year, but this change is not statistically significant (p-value = 0.139). These fluctuations indicate potential variability in alcohol consumption patterns among younger age groups over the years following the tax increase.

In Table 9, which focuses on the age group of 45-65+ years old, similar fluctuations in alcohol prevalence are observed. For instance, in 2013, there is a decrease in alcohol prevalence among 45-54-year-olds by 2.47 percentage points compared to the previous year, following the tax increase. However, this change is not statistically significant (p-value = 0.348). Conversely, in 2014, there is a decrease in alcohol prevalence among the 65+ age group by 1.97 percentage points compared to the previous year, but again, this change is not statistically significant (p-value = 0.418). Notably, in 2016, we report a statistically significant decrease in alcohol prevalence among the 65+ age group by 6.58 percentage points (p-value = 0.070), suggesting a potential impact of the tax increase on this demographic in the later years. Overall, despite fluctuations observed in alcohol prevalence among different age groups following the tax increase in 2011, the statistical analysis suggests that there was no significant change in consumption.

In our analysis, we employed the synthetic control method to examine the impact of a tax increase on alcohol consumption patterns. To ensure the validity of our findings, we assessed the parallel trend assumption. Our analysis revealed that for the age groups 25-34 and 35-44, the parallel trend assumption held true, as evidenced by the consistent trends observed in Figures 14. However, it's noteworthy to mention that for other age groups, particularly those outside the 25-34 and 35-44 brackets, the synthetic control method did not yield perfect results. This discrepancy could be attributed to several factors, including the granularity of the data and amount of the predictors jointly minimized during the analysis.

Finally, we note that the change in wine consumption observed in the last section is not directly reflected in the total self-reported alcohol consumption data. This is because our the dataset does not differentiate between different types of alcoholic beverages, and any changes in alcohol prevalence may not accurately represent specific trends in wine, beer, or spirits consumption individually. Therefore, while wine consumption may be declining according to the previous sales analysis, the total alcohol consumption data remained relatively stable. We can further conclude that the change in wine consumption appears to be marginal compared to the total self-reported consumption of alcohol.

5.3 Health outcomes

In this section, we assess the impact of a tax increase on various health outcomes, focusing on Connecticut counties as the treatment group and comparing them with counties from Maryland (MD), Maine (ME), Minnesota (MN), and New Hampshire (NH) as the control group selected based on the results of the previous synthetic control method described in Section 4. We modeled health outcomes (Y_{ct}) for each county (c) over time (t), incorporating the following variables: binge drinking prevalence, poor/fair health, chlamydia rate, and premature death. We controlled for county-specific characteristics (χ_c) through control variables such as age, income, marital status, education, and unemployment rate. To address unobserved heterogeneity, we also incorporated state (λ_c) and time (λ_t) fixed effects into our model.

Our results, as detailed in Table 10, report the estimated coefficients (γ_3) for the interaction term representing the tax increase. However, none of these coefficients were found to be statistically significant. Specifically, the coefficients for the tax increase on binge drinking prevalence, poor/fair health, chlamydia rate, and premature death all failed to reach statistical significance. These findings suggest that the observed tax increase did not have a discernible effect on any of the four health outcomes under investigation. In conclusion, our analysis did not find evidence to support the hypothesis that the tax increase had a significant impact on health outcomes in the studied counties, in the short-run.

This result is coherent with the literature. Indeed, Nelson (2015) demonstrated through a comprehensive review of fifty-six relevant econometric studies that binge drinkers are not highly responsive to increased prices. In this setting, null results were found in more than half of the studies. Particularly, the non-responsiveness holds generally for both younger and older drinkers, as well as for male and female binge drinkers alike (Nelson, 2015). More recent studies have reinforced this conclusion (Nelson & McNall, 2017).

6. Discussion

Despite minimal shifts in consumption patterns, the state of Connecticut experienced a substantial increase in excise tax revenue, amounting to 23.86%. This surge in revenue happened even though consumer behavior remained relatively unchanged. In other words, the tax policy effectively bolstered government income without causing significant deadweight loss (DWL). In our analysis, the demand for alcohol behaved in a relatively inelastic way following the moderate increase in taxes, particularly for beer and spirits. Connecticut increase in taxation generated considerable revenue for the state without inducing substantial shifts in consumption.

Research supports the idea that the original point of departure for the economic theory of optimal taxation is applying taxes to markets where the aggregate deadweight loss is minimized (Sandmo, 1975). Indeed, stable consumer attitudes and behavior in tax policy implementation is crucial in evaluating efficient taxation. Our analysis of the market suggested that the deadweight loss has been minimized for the beer and spirit market, since no significant change in the sales has been recorded.

The findings from the analysis can have external applicability to other state alcohol markets. Policymakers can learn from Connecticut's experience in evaluating the effectiveness of their current tax policies on alcohol. Indeed, it is highly probable that states may have suboptimal tax rates on alcohol, resulting in a missed opportunity to generate additional revenue without significantly impacting consumer behavior. This likelihood is accentuated by the historical trend of decreasing taxes on alcohol over time (Tax Policy Center, 2017). By adjusting tax rates upwards to more optimal levels, states could potentially increase revenue without causing substantial shifts in consumption patterns.

If moderate increase in taxation does not correlate significant increase in health outcomes, states can however use the increase in revenue collected to maximize public health benefits. Investing in prevention initiatives emerges as a promising avenue, as evidenced by studies demonstrating the positive impact of prevention programs on youth alcohol consumption (Le, 2023). Additionally, more comprehensive alcohol control measures, especially those impacting alcohol accessibility and advertising, correlate with reduced rates and frequency of alcohol consumption among adolescents, as well as a delay in the age at which they first start drinking (Paschall, 2009). By targeting preventive measures, such as education campaigns and community interventions, policymakers can address underlying factors contributing to alcohol misuse and promote healthier behaviors among vulnerable populations. Moreover, directing resources towards treatment programs can provide support for individuals struggling with alcohol addiction and related health issues. By expanding access to rehabilitation services and mental health support, policymakers can mitigate the adverse effects of excessive alcohol consumption and improve overall well-being in affected communities.

Minimizing deadweight loss is a key consideration in optimizing tax systems, yet it is not the sole determinant. Justice and fairness in taxation, as discussed by Sandmo (1975), also factor into the equation. One argument against the increase in alcohol taxes is that doing so would unfairly burden "responsible" drinkers, those who consume alcohol with lower associated risks, with a significant financial strain (Daley, 2012). As Feldstein (1972) summarizes, there exists an inherent tradeoff between efficiency and equity in tax policy. Policymakers are tasked with navigating this tradeoff, balancing the imperative of maximizing economic efficiency with the need to ensure a fair distribution of the tax burden across society. Indeed, the economic fairness of alcohol taxes raise questions about who bears the financial burden of tax increases and how these policies impact different segments of society.

However, contrary to the perception that moderate tax increases disproportionately affect responsible drinkers, recent studies suggest that higher-risk drinkers bear the majority of the net tax increase. Analyzing BRFSS Data, Daley (2012) assessed the impact of a 25 cents per drink increase in alcohol tax. He concluded that the increase in tax resulted in a reduction in excessive drinking, with the bulk of the increased tax burden falling on higher-risk drinkers. Specifically, in the examined scenario, higher-risk drinkers paid 4.7 times more in net increased annual per capita taxes compared to lower-risk drinkers. Additionally, they paid 82.7% of the net increased annual aggregate taxes, while lower-risk drinkers experienced an annual tax increase of less than $30 (Daley, 2012). Further research corroborates these findings: in the face of alcohol tax increases, consumers from higher-income households and non-Hispanic white individuals would incur greater per capita expenses compared to those with lower incomes and members of racial or ethnic minority groups (Naimi, 2016). Across states, excessive drinkers would shoulder 4.8 to 6.8 times the per capita expenses compared to non-excessive drinkers and would contribute to at least 72% of the total costs. Non-excessive drinkers would face an average annual cost of less than $10 (Naimi, 2016).

7. Conclusions

This paper studies the impacts of the Connecticut 2011 tax increase (+20%) on alcohol consumption and related health outcomes. We use difference-in-difference models and synthetic control method to investigates the dynamics between tax policies, consumer behavior, and public health. Overall, the tax policy boosted Connecticut Alcohol Tax Revenue Collection by 23%, without major alterations in alcohol consumption patterns and health outcomes besides a stable decrease in wine consumption of around 10 glasses per capita per year in the period following the tax increase. These findings contribute to the ongoing discussion on the efficacy of tax policies in addressing public health concerns.

First, the analysis of government revenue following the implementation of the 20% tax increase on alcohol in Connecticut in 2011 reveals a significant increase in revenue during Fiscal Year 2012 compared to preceding fiscal years. This increase, amounting to \$11.67 million, represents a substantial rise of approximately 23.86% compared to Fiscal Year 2011. Importantly, statistical analysis and graphical representations demonstrate that this increase in revenue cannot be attributed to changes in the quantity of alcohol taxed, thus indicating a direct impact of the tax increase on revenue generation. These findings underscore the effectiveness of the tax policy in bolstering government income without significant alterations in consumer behavior.

Second, the examination of alcoholic beverage sales data using the synthetic control method reveals nuanced effects of the tax increase on consumption patterns. While there were no statistically significant deviations observed in beer and spirit consumption, a notable decrease in wine consumption is evident following the tax change. This decline in wine consumption, coupled with the lack of significant changes in beer and spirit consumption, suggests differential impacts of the tax increase on various alcoholic beverages. The findings are consistent with existing literature, highlighting the importance of considering beverage-specific responses to tax policies. Moreover, the analysis of self-reported alcohol consumption data indicates fluctuations in alcohol prevalence among different age groups following the tax increase. Statistical analysis suggests that these fluctuations were not statistically significant overall. No statistically significant changes in alcohol consumption patterns were observed across age groups.

Third, the evaluation of the impact of the tax increase on health outcomes reveals no statistically significant effects across four key variables: binge drinking prevalence, poor/-fair health, chlamydia rate, and premature death. Our analysis did not find evidence to support the hypothesis that the tax increase had a significant impact on health outcomes in the studied counties. These results align with existing literature, which suggests that binge drinkers and other health outcomes are generally not highly responsive to increased prices in the short run (Nelson, 2015), thereby reinforcing the conclusion that the observed tax increase did not lead to discernible changes in health outcomes in the 5 years following the increase in taxes.

Several avenues for future research could be explored to further understand the effects of tax policies on alcohol consumption and health outcomes. One potential area of investigation could involve examining the burden of the tax increase on consumers and sellers by studying changes in prices and sales data. Using data from sources such as Nielsen IQ scanner could provide insights into how changes in taxes impact the prices of alcoholic beverages and subsequent consumer purchasing behavior. Additionally, accessing more long-term data could offer valuable insights into the sustained effects of tax increases on alcohol consumption and health outcomes. By analyzing trends over a more extended period, researchers could better understand the long-term implications of tax policies on public health and make more informed policy recommendations. Furthermore, future research could explore the potential interaction effects between tax policies and other interventions aimed at reducing alcohol-related harms. For example, investigating how tax increases interact with public health campaigns or regulatory measures could provide insights into the most effective strategies for addressing alcohol-related issues.

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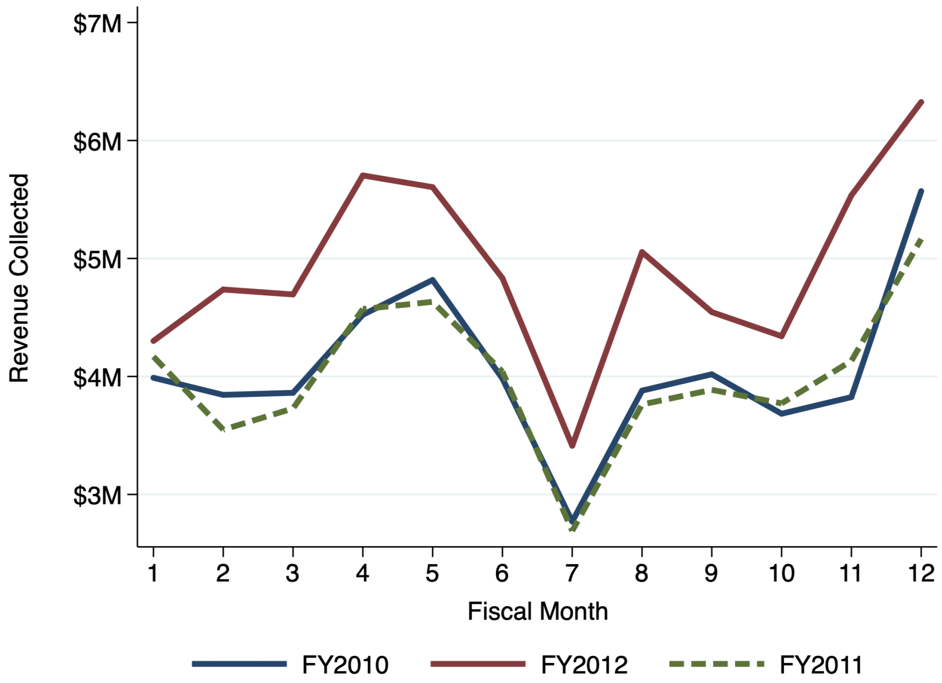
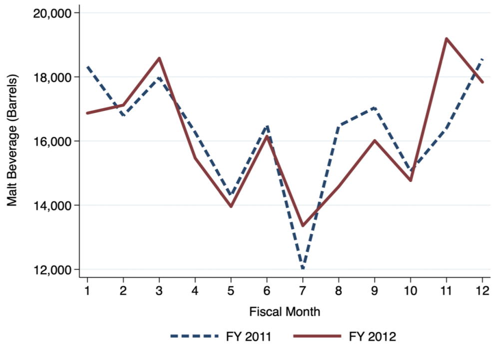
Figure 1: Revenue collected from Alcohol Specific Excise Taxes in Connecticut



Note: The figure depicts revenue collected over 12 months for fiscal years 2010, 2011, and 2012, with each year represented by a separate line. Preceding a tax increase in July 2012, 2010 and 2011 show similar revenue levels, while 2012 demonstrates a significant upward shift post-implementation. The consistent shape across years suggests revenue collection's seasonal patterns and implies inelasticity. Additionally, the area between the 2012 and 2011 curves signifies the extra revenue from the tax hike, totaling $11.67 million, directly illustrating its impact.

Figure 2: Change in Quantity of Alcoholic Beverage Taxed



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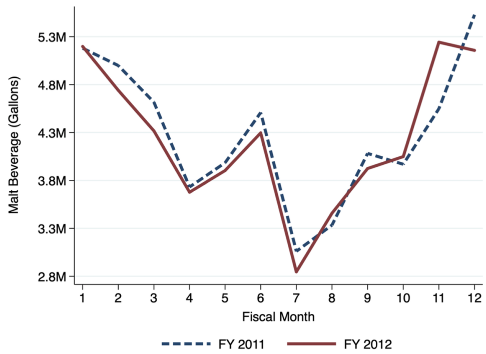

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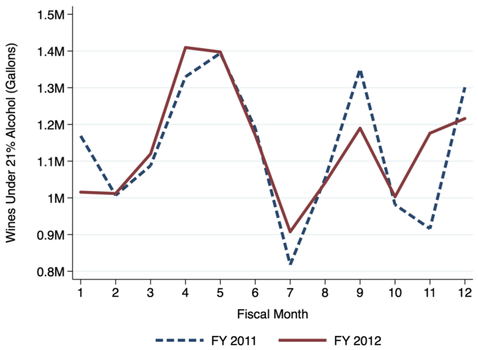

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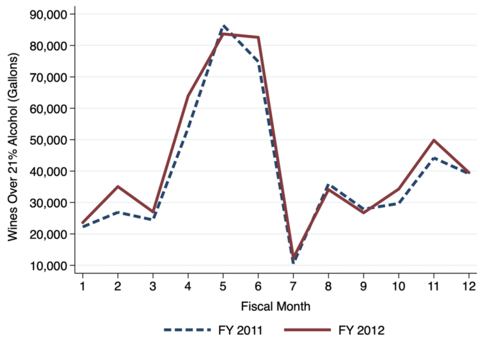

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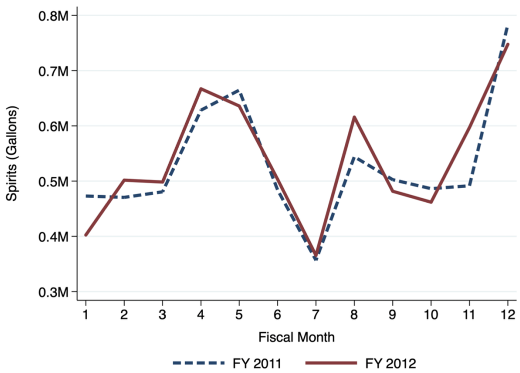
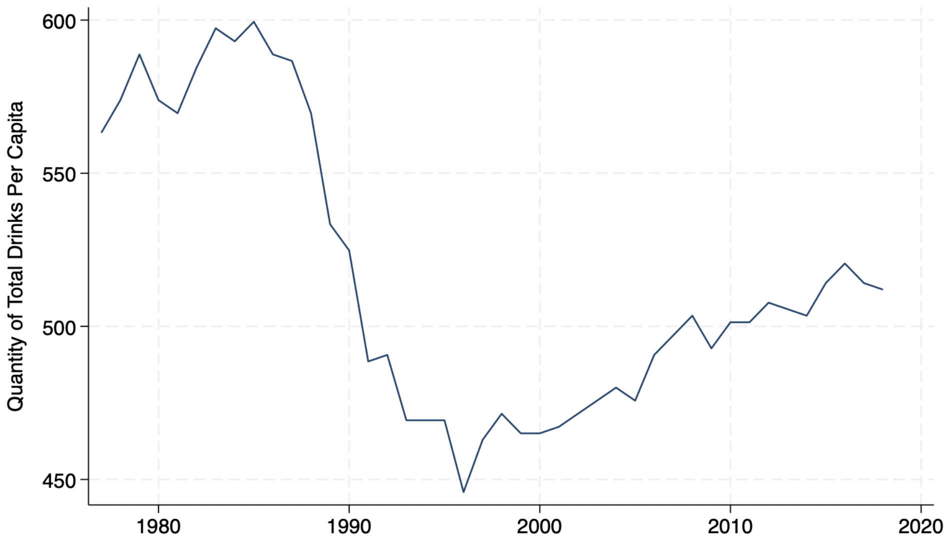


(e)

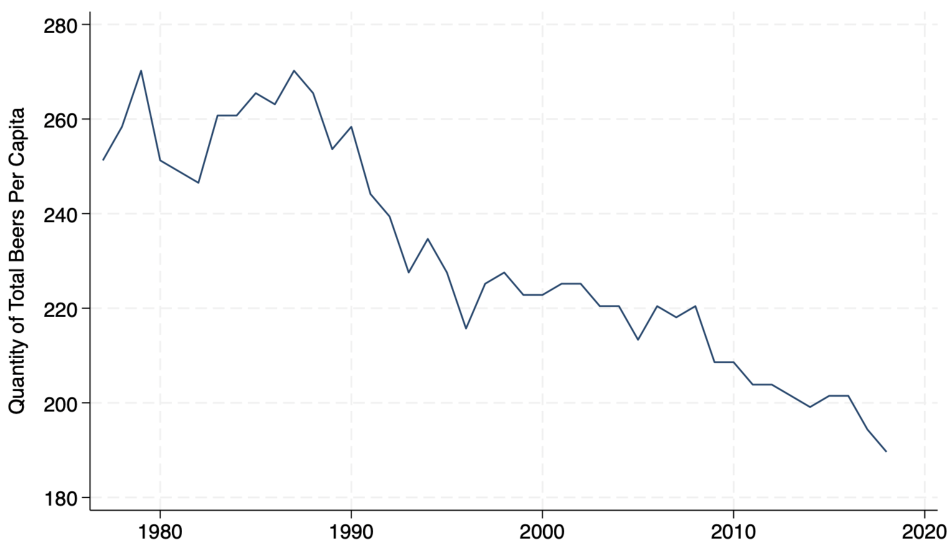
Note: Those figures describe the change in Barrels of Malt Beverage Taxed (a), Change in Gallons of Malt Beverage Taxed (b), Change in Gallons of Wines Under 21% Alcohol Taxed (c), Change in Gallons of Wines Over 21% Alcohol and Sparkling Wines Taxed (d), and change in Gallons Spirit Taxed (e). The argument is that the quantity of alcohol taxed did not increase or decrease. One possibility is that the price of alcohol has remained stable (placing the burden on the seller), although this hypothesis may be challenged following Conlon and Rao's work (2016). Another possibility is that the price has increased, but alcohol exhibits very low elasticity. This latter hypothesis is confirmed.

Figure 3: Evolution of Connecticut Total Alcohol Consumption Per Drinks Per Capita



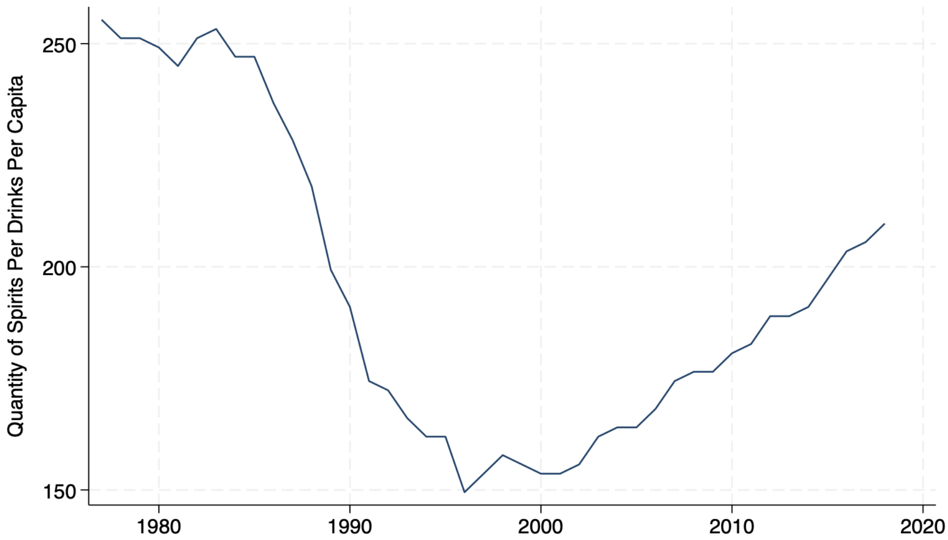
Note: The figure depicts the change in total alcohol consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the steep decrease in consumption between 1983 and 1995.

Figure 4: Evolution of Connecticut Beer Consumption Per Drinks Per Capita



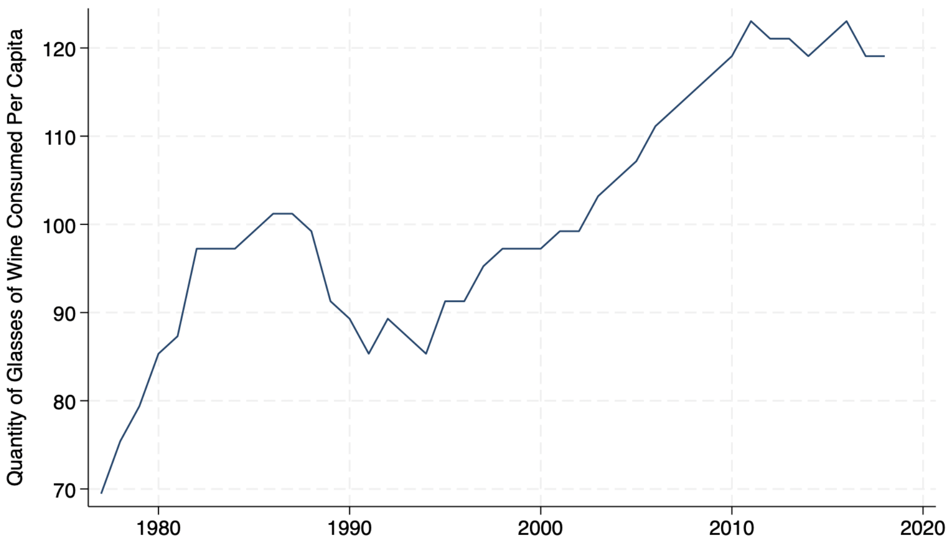
Note: The figure depicts the change in beer consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. Unlike wine consumption, beer consumption among Connecticut residents has been declining over time.

Figure 5: Evolution of Connecticut Spirit Consumption Per Drinks Per Capita



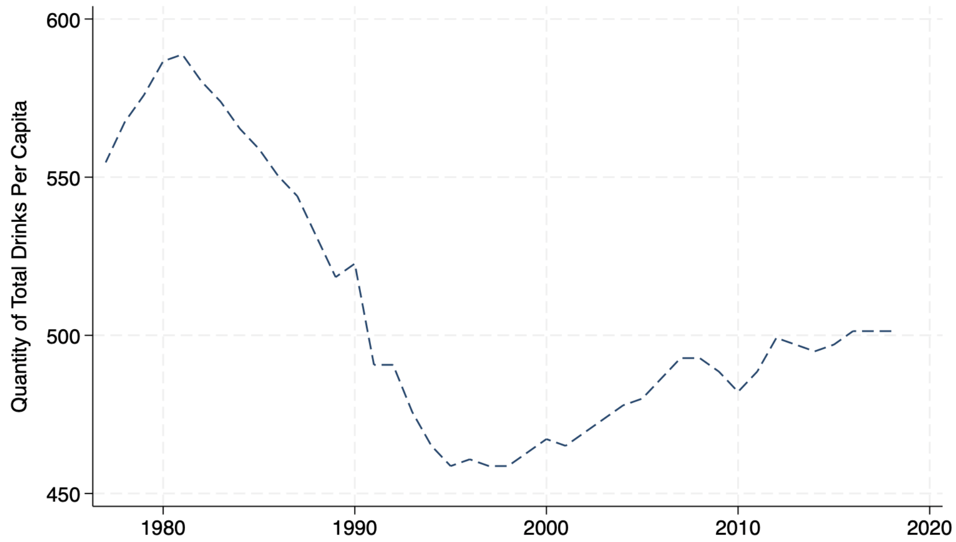
Note: The figure depicts the change in spirit consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the decrease in consumption between 1986 and 1995.

Figure 6: Evolution of Connecticut Wine Consumption Per Drinks Per Capita



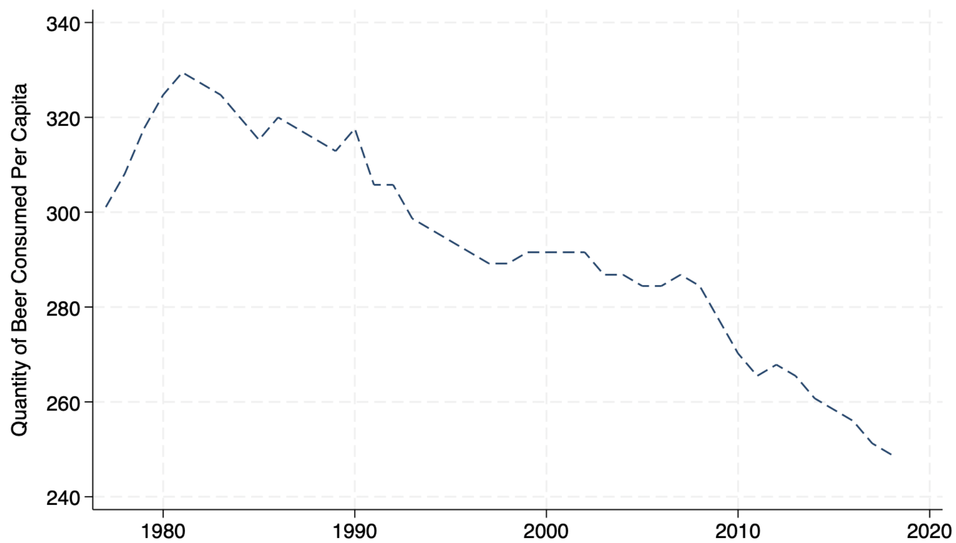
Note: The figure depicts the change in wine consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the decrease in consumption between 1986 and 1995. Furthermore, wine consumption seems to have slightly decreased following the increase in alcohol tax in 2009.

Figure 7: Evolution of US Total Alcohol Consumption Per Drinks Per Capita



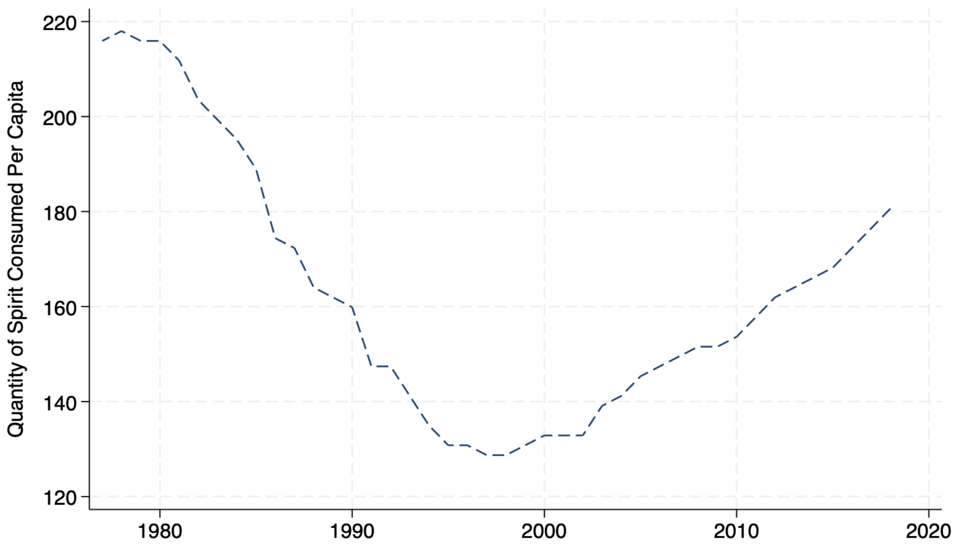
Note: The figure depicts the change in total alcohol consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the steep decrease in consumption between 1983 and 1995.

Figure 8: Evolution of US Beer Consumption Per Drinks Per Capita



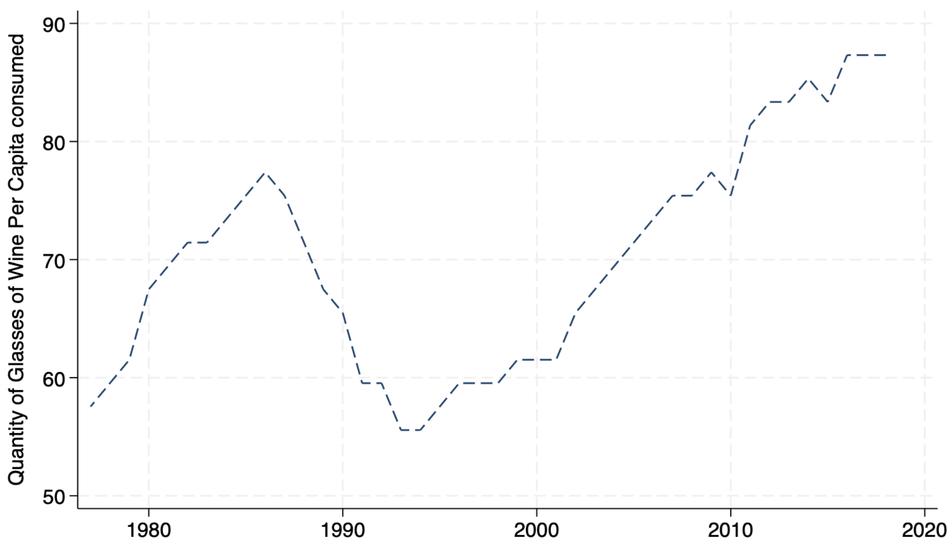
Note: The figure depicts the change in beer consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. Unlike wine consumption, beer consumption among Connecticut residents has been declining over time.

Figure 9: Evolution of US Spirit Consumption Per Drinks Per Capita



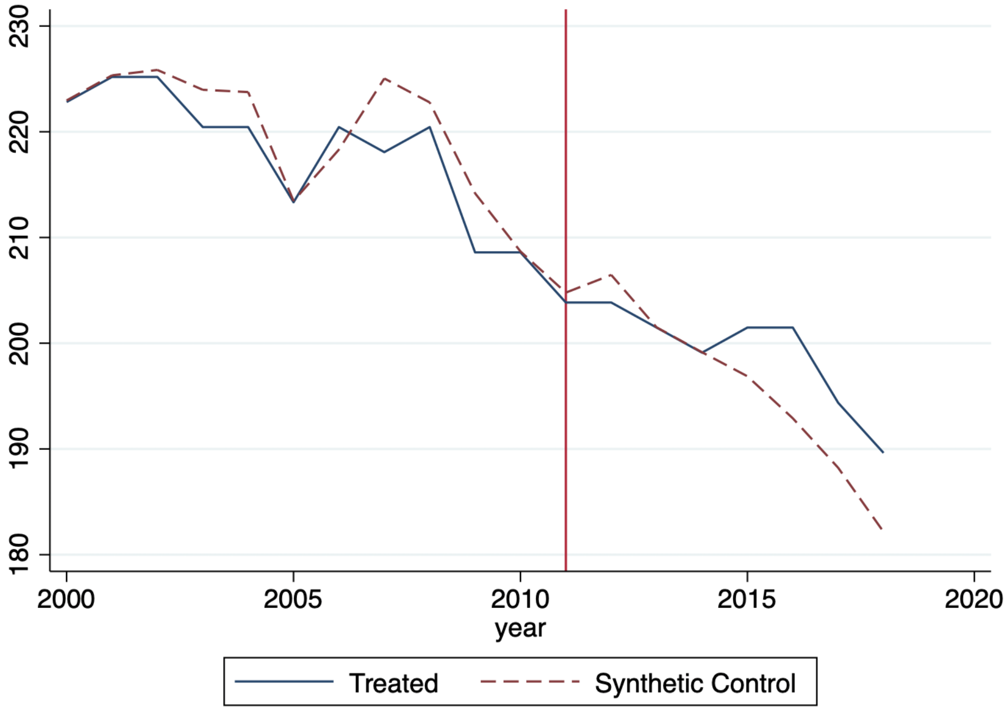
Note: The figure depicts the change in spirit consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the decrease in consumption between 1986 and 1995.

Figure 10: Evolution of US Wine Consumption Per Drinks Per Capita



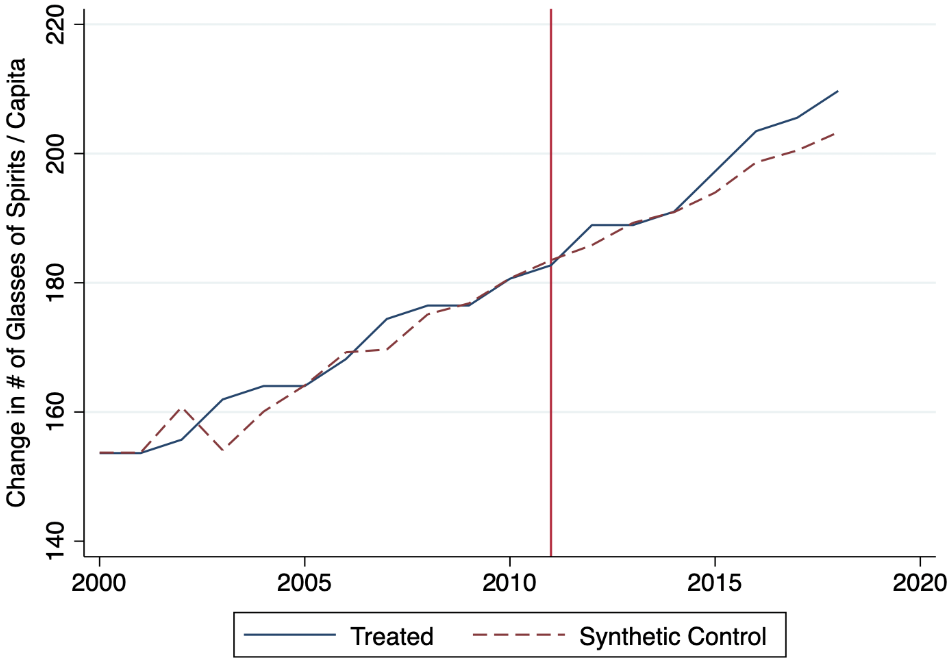
Note: The figure depicts the change in wine consumption in Connecticut, measured in drinks per capita, from 1977 to 2018. The drinking age in the state has changed several times over the years, including a raise to 20 in 1983, followed by an increase to 21 in 1985, which may have driven the decrease in consumption between 1986 and 1995. Furthermore, wine consumption seems to have slightly decreased following the increase in alcohol tax in 2009.

Figure 11: Evolution of the quantity of beers consumed per capita from 2000 to 2018



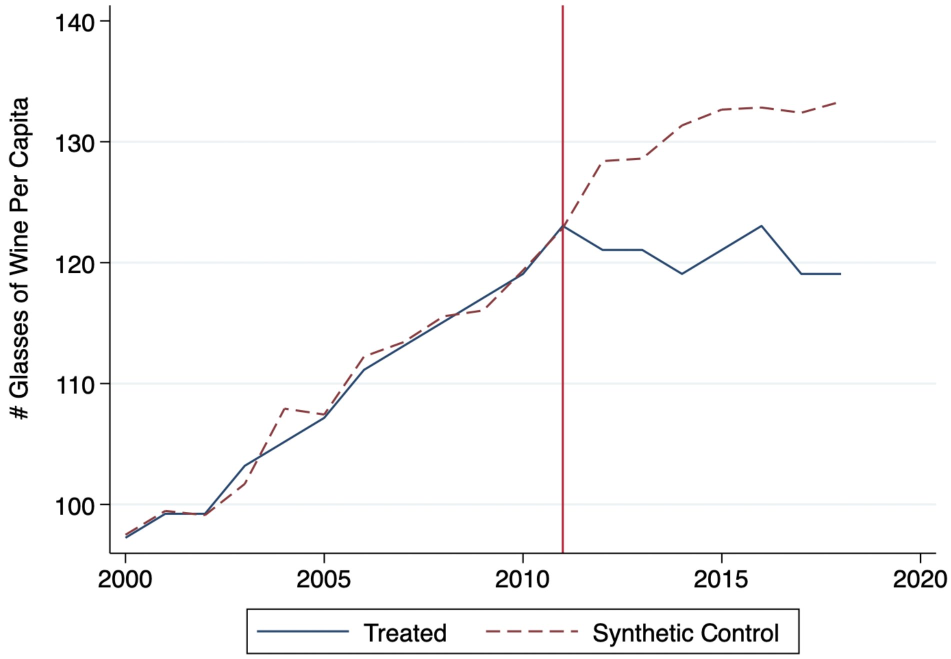
Note: This graph illustrates the change in the number of beers consumed per capita from 2000 to 2018 in Connecticut. Upon visual inspection, the graph reveals no statistical changes and may even suggest a relative increase. This visual observation is further supported by the p-value, a statistical measure of significance, provided alongside Figure 7.

Figure 12: Evolution of the quantity of spirits consumed per capita from 2000 to 2018



Note: This graph illustrates the change in the quantity of Spirit consumed per capita from 2000 to 2018 in Connecticut. Upon visual inspection, the graph reveals no statistical changes following the implementation of the tax hike. The findings are reflected in Table 7.

Figure 13: Evolution of the quantity of wine consumed per capita from 2000 to 2018

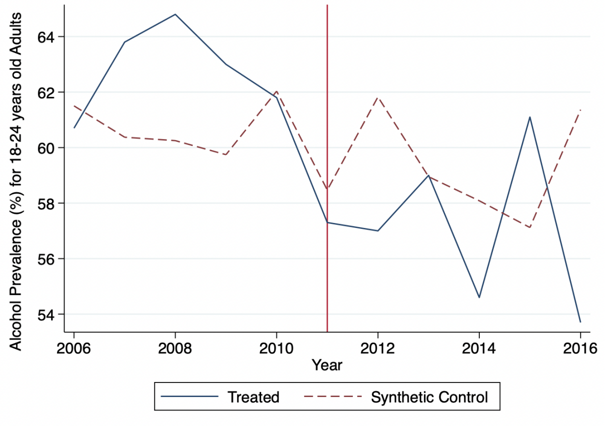


(a)

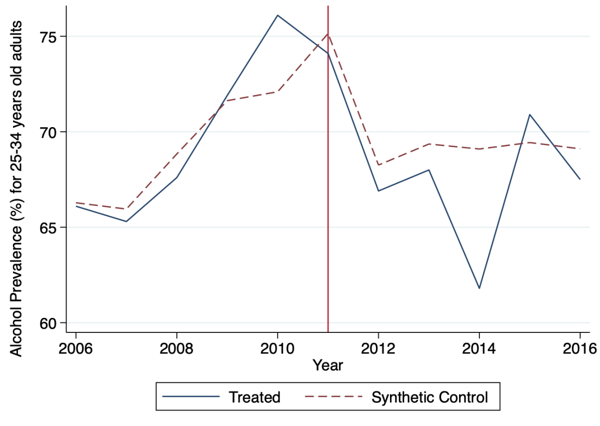
(b)

Note: Change in Wine Consumption over time measured in Glasses Per Capita, from 2000 to 2018 (a) and difference in value between treated and synthetic control group over time (b). The analysis of wine consumption reveals a significant deviation, showing a decrease of approximately 7 glasses per capita immediately following the increase in taxes, and between 11 and 14 glasses per capita per year for the years after. This decrease is highly significant, with p-values significant at the 5% confidence level for 2012, 2013, and 2016, and significant at the 0.1% level for the other years (Table 7).

Figure 14: Alcohol Prevalence (%) by age group



(a)



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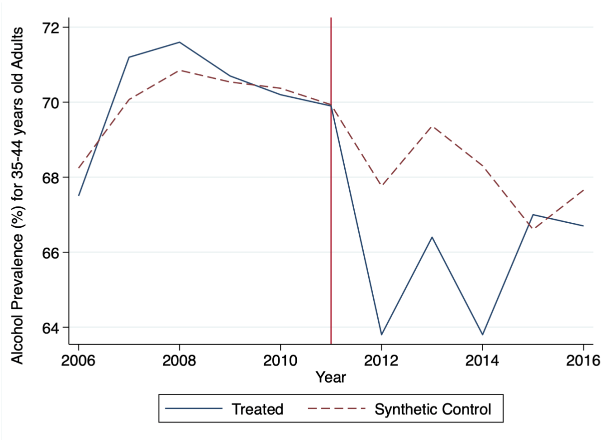

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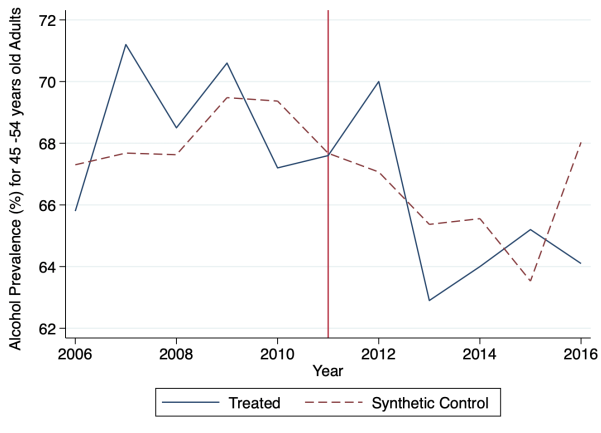

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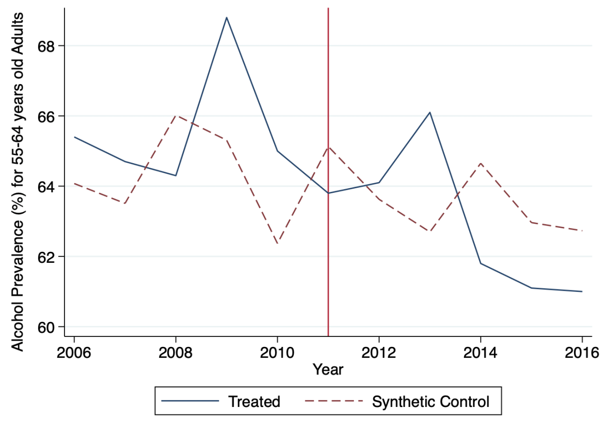

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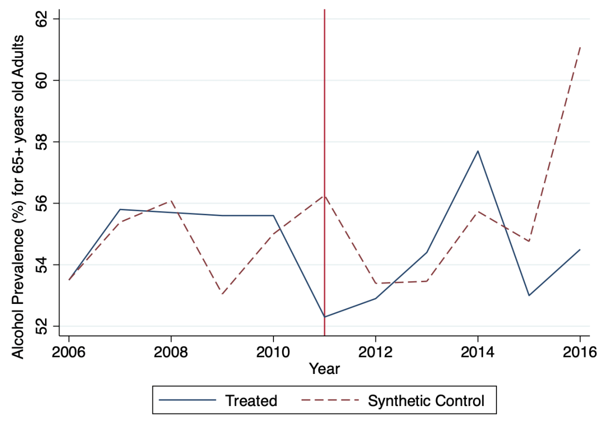


(f)

Note: These graphs show the alcohol Prevalence for 18-24 years old adults (a), for 25-34 years old adults (b), for 35-44 years old adults (c), for 45-54 years old adults (d), for 55-64 years old adults (e), for 65+ years old adults (f). For the age groups 25-34 and 35-44, the parallel trend assumption held true. Despite fluctuations observed in alcohol prevalence among different age groups following the tax increase in 2011, the statistical analysis suggests that there was no significant change in consumption.

Table 1: Data Source and Time Period

Data Source	**Variables**	**Years**
Department of Revenue Services of the State of Connecticut	Revenue collected from Alcohol Tax	2009 to 2013
*AEDS**, *NABCA**, *NIAAA**	Alcoholic beverage Sales	2000 to 2018
*BRFSS**	Alcohol consumption	2009 to 2016
	Binge Drinking	2009 to 2016
	Fair or Poor Health	2009 to 2016
*NCHS**	Premature death rate	2009 to 2016

Note: Alcohol Epidemiologic Data System (*AEDS*), National Alcohol Beverage Control Association (*NABCA*), National Institute on Alcohol Abuse and Alcoholism (*NIAAA*), Behavioral Risk Factor Surveillance System (*BRFSS**) and National Center for Health Statistics (*NCHS**)

Table 2: Alcoholic Beverages Sales Summary Statistics

	Count	**Mean**	**SD**	**Max**	**Min**
Alcohol Variables					
# of Beers	561	286.47	52.68	149.33	450.37
# Glasses of Wine	561	80.55	40.63	19.84	236.16
# Shots of Liquor	561	176.77	58.80	85.12	413.1711
# Total Drinks	561	526.09	116.47	283.73	1015.47
Controls					
Median Age (Male)	561	36.3	2.3	27.7	43.3
Median Age (Female)	561	38.8	2.5	29.1	45.7
Per Capita Income ($)	561	27,464	4,830	18,165	50,567
Married Rate (%)	561	49.64	5.07	24.10	59.52
Bachelor Degree (%)	561	17.92	2.86	9.95	24.94
High School Degree (%)	561	26.69	4.70	14.78	42.69

Note: The table provides the summary statistics for Alcoholic Beverage Sales. The dataset comprises the 50 US states and Puerto Rico, spanning 11 years (2006 to 2016), resulting in 561 observations. This dataset is based on alcoholic beverage sales data gathered by the Alcohol Epidemiologic Data System (AEDS) from state sources or the National Alcohol Beverage Control Association, along with industry reports (referenced in Table 1). AEDS employs an average ethanol content estimate to convert gallons of beer, wine, and spirits sold or shipped into gallons of pure ethanol, subsequently calculating per capita consumption rates using population data from the U.S. Census Bureau.

Table 3: Alcohol Prevalence BRFSS Summary Statistics

	Count	Mean	SD	Max	Min
Alcohol Variables 18-24					
Prevalence (%)	544	51.08	8.46	71.1	15.5
Sample size	588	187.82	131.53	980	20
Alcohol Variables 25-34					
Prevalence (%)	585	60.36	9.13	84.5	25.6
Sample size	588	465.18	285.54	2217	53
Alcohol Variables 35-44					
Prevalence (%)	587	58.06	9.75	76	26.6
Sample size	588	623.27	384.94	2763	44
Alcohol Variables 45-54					
Prevalence (%)	588	55.02	10.31	73.8	24.9
Sample size	588	829.04	522.98	3726	43
Alcohol Variables 55-64					
Prevalence (%)	587	49.97	10.77	68.8	20.8
Sample size	588	905.76	595.11	4283	34
Alcohol Variables 65+					
Prevalence (%)	587	39.01	11.10	61.2	10.9
Sample size	588	1028.30	771.21	6052	17
Controls					
Median Age Male	572	36.29	2.24	43.3	27.7
Median Age Female	572	38.85	2.48	45.7	29.1
Per capita income ($)	572	27,141	5,313	50,567	9,474
Married Rate (%)	572	49.45	5.23	59.52	24.10
Bachelor Degree (%)	568	17.92	2.84	24.94	9.95
High School Degree (%)	568	26.66	4.68	42.69	14.78

Note: The table presents summary statistics for BRFSS Alcohol Prevalence by age group, encompassing data from the 50 US states, Puerto Rico, Guam, and the Virgin Islands, spanning 11 years (2006 to 2016). The sample size denotes the number of individuals surveyed by age group and by state. In some instances, the sample size was less than 100, resulting in the omission of prevalence values. Consequently, the count of sample sizes may exceed the count of prevalence. Additionally, the sample size of surveyed individuals increases with advancing age groups; thus, there are more individuals surveyed in the 65+ group compared to the 18-24 group. Read: The average Alcohol Prevalence in the 18-24 years old age group is 51.08%. In other words, 51.08% of Adults aged 18 to 24 years old have had at least one drink of alcohol within the past 30 days.

Table 4: Connecticut Change in Alcohol Excise Tax Rates, 1982 through 2023

Effective Period	**Spirits**	**Beer**	**Wine**
2020 - 2023	5.94	0.24	0.79
2012 - 2019	5.40	0.24	0.72
1990 - 2011	4.50	0.19	0.60
1984 - 1989	3.00	0.10	0.30
1982 - 1883	2.50	0.08	0.25

Note: The table illustrates Connecticut tax rates on distilled spirits, beer, and wine excise tax rates, as of January 1st, in dollars per gallon ($). Alcohol tax rates are converted into a standard measure of dollars per gallon. For wine, we choose the tax rate assigned to still as opposed to sparkling wine, and select the rate for the lowest alcohol by volume (ABV). For spirits, we choose the rate associated with 50% ABV or less. Sources: Tax Policy Center, Federation of Tax Administrators, the Tax Foundation, the Council of State Governments, the Advisory Commission on Intergovernmental Relations, the Distilled Spirits Council of the United States.

Table 5: Fiscal Year Total Revenue Cumulative and Change (in million of $)

Fiscal Year	Total Revenue Cumulative	Change from Previous Year
2009	47.06	–
2010	48.20	1.13
2011	48,92	0.73
2012	**60,60**	**11.67**
2013	**60,41**	(0.19)

Note: The table illustrates the total revenue accumulated over fiscal years alongside the year-on-year changes. Particularly noteworthy is the significant and consistent rise in revenue during Fiscal Year 2012 compared to preceding years. This upsurge correlates with the implementation of a 20% tax hike effective July 1, 2012, resulting in an additional annual collection of $11.67 million, marking a surge of approximately 23.86% compared to FY2011.

Table 6: T-Test Results for Various Variables by Fiscal Year

Variable	**Mean Difference**	**T-Statistic**	***p*-value**
Beer (Barrels)	149.67	0.2002	**0.4216**
Beer (Gallons)	61189.67	0.2015	**0.4211**
Wine ($<$ 21%) (Gallons)	-5101.58	-0.0730	**0.5288**
Wine ($>$ 21%) (Gallons)	-3067.42	-0.3328	**0.6288**
Spirit (Gallons)	-9351.25	-0.2035	**0.5797**

Note: The results of the t-tests indicate that there are no statistically significant changes in the quantity of alcohol taxed before and after the implementation of tax increases, effective July 2011. The t-statistic values for each beverage type are relatively small, indicating that the observed mean differences are not substantial relative to the variability within the data. Additionally, the p-values associated with each t-test are greater than the conventional significance level of 0.05, suggesting that we fail to reject the null hypothesis that there is no difference in the quantity of alcohol taxed between FY2011 and FY2012. Therefore, based on these results, it appears that the tax increases implemented in July 2011 did not have a significant impact on the quantity of alcohol taxed across different beverage types.

Table 7: Changes in Alcohol Sales per capita

	Wine		Beer		Spirit	
Year	Estimates	P-value	Estimates	P-value	Estimates	P-value
2011	0.18	0.94	-0.94	0.84	-0.77	0.82
2012	-7.35*	**0.02**	-2.61	0.62	3.10	0.60
2013	-7.55*	**0.02**	-0.02	0.98	-0.34	0.92
2014	-12.28***	**0.00**	-0.03	1.00	0.08	1.00
2015	-11.61***	**0.00**	4.60	0.62	3.28	0.74
2016	-9.79*	**0.04**	8.58	0.34	4.83	0.74
2017	-13.33***	**0.00**	6.15	0.48	5.07	0.72
2018	-14.25***	**0.00**	7.47	0.42	6.41	0.66

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: This table presents the changes in alcohol sales per capita per year for three beverage categories: wine, beer, and spirits. Each row corresponds to a specific year after the 2011 increase in tax, and each column provides estimates of the change in consumption for the respective beverage, along with the associated p-values indicating the statistical significance of these changes. For instance, in 2012, the table indicates a substantial decrease in wine consumption per capita, with an estimate of -7.35. This means that, on average, individuals consumed 7.35 fewer units of wine compared to the previous year. Importantly, this change is statistically significant (p = 0.02), suggesting that the decrease in wine consumption per capita observed in 2012 is unlikely to have occurred by random chance.

Table 8: Changes in Alcohol Prevalence by Age Group (18-44)

	18-24 Years Old		25-34 Years Old		35-44 Years Old	
Year	Estimates	P-value	Estimates	P-value	Estimates	P-value
2011	-1.17	.953	-1.05	.791	-.03	1
2012	-4.83	.767	-1.36	.744	-3.96	.209
2013	0.05	1.00	-1.36	.628	-2.97	.232
2014	-3.48	.767	-7.29	.139	-4.51	.209
2015	3.98	.674	1.47	.791	.39	.814
2016	-7.66	.605	-1.61	.651	-.96	.767

Table 9: Changes in Alcohol Prevalence by Age Group (45-65+).

	45-54 Years Old		55-64 Years Old		65+ Years Old	
Year	Estimates	P-value	Estimates	P-value	Estimates	P-value
2011	-0.07	.930	-1.33	.488	-3.96	.140
2012	2.93	.209	0.47	.860	-.50	.884
2013	-2.47	.348	3.40	.139	.94	.697
2014	-1.56	.442	-2.85	.139	1.97	.418
2015	1.67	.581	-1.86	.674	-1.76	.511
2016	-3.93	.279	-1.73	.697	-6.58	.070

Note: Those tables present estimates and p-values for changes in alcohol prevalence among the age groups, following the increase in alcohol tax in 2011. For each age group, they show the estimated changes in alcohol prevalence compared to the previous year, along with corresponding p-values indicating statistical significance. Overall, the table allows for the assessment of trends in alcohol consumption within different age demographics and provides insights into the statistical significance of these trends over time. *Read: After the tax increase in 2012, the consumption among the 18-24 age group decreased by 4.83 percentage points compared to 2011. However, this change is not statistically significant, as indicated by the p-value of 0.767.*

Table 10: Health Outcomes Analysis: Difference-in-Difference Regression

	(1) Binge Drinking	(2) P/F Health	(3) Chlamydia	(4) Premature Death
Interaction (γ_3)	0.921	-0.213	-24.35	171.9
	(0.40)	(-0.13)	(-0.55)	(0.27)
Controls	Y	Y	Y	Y
State Fixed Effect	Y	Y	Y	Y
Time Fixed Effect	Y	Y	Y	Y
N	959	959	959	959

t-statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The table displays the estimated coefficients for the interaction term representing the effect of a tax increase on various health outcomes: Binge Drinking, Poor/Fair Health, Chlamydia Rate, and Premature Death. The values in parentheses represent the t-statistics. Controls, state fixed effects, and time fixed effects are included in the analysis. However, none of the coefficients were statistically significant at the 0.05 level. The sample size for each outcome is 959.

A. Appendix: Synthetic Control Method

The synthetic control method is a statistical technique used to evaluate the effects of an intervention or treatment when traditional experimental designs are not feasible (Abadie, 2010). It involves constructing a "synthetic" control group that closely mimics the characteristics and outcomes of the treated group prior to the intervention. This is achieved by selecting a weighted combination of untreated units, such as states in our paper, in a way that minimizes the mean-squared prediction error (MSPE) during the pre-intervention period. The weights assigned to each untreated unit reflect their contribution to matching the outcomes of the treated unit. After constructing the synthetic control group, the treatment effect is estimated by comparing the outcomes of the treated group with those of the synthetic control group.

In the following tables, we display the weights assigned to each state and illustrate how the predictor variables are minimized during the pre-treatment period for alcohol sales consumption. Table A1 presents the value of the predictors for the pre-treatment period, with difference in the values of the predictors minimized by the synthetic control method. Table A2 presents the weights assigned to each unit, used to construct the synthetic control group. For example, in the beer analysis, the synthetic control group comprises 51.1% Utah, 30.2% Maryland, 11.3% Delaware, 5.5% Arkansas, and 1.9% Alaska.

Table A1: Pre-treatment Predictors Balance for the Alcohol Sales Analysis

	Wine		Beer		Spirit	
Predictor	Treated	Synthetic	Treated	Synthetic	Treated	Synthetic
# of drinks (2006)	111.13	111.28	220.44	217.80	168.17	167.72
# of drinks (2007)	113.11	113.27	218.07	221.30	174.40	173.96
# of drinks (2008)	115.10	115.26	220.44	218.69	176.48	176.03
# of drinks (2009)	117.08	117.25	208.59	211.05	176.49	176.04
# of drinks (2010)	119.06	119.23	208.59	207.60	180.63	180.18
Median Age Male	37.9	35.5	37.9	36.2	37.98	35.65
Median Age Female	40.7	37.7	40.7	33.9	40.7	38.35
Per Capita Income ($)	35,634	29,475	35,634	26,363	35,634	24,918
Marriage Rate (%)	51.63	48.85	51.63	54.86	51.63	52.84
Bachelor degree (%)	19.84	18.28	19.84	18.80	19.84	17.21
High School Degree (%)	28.08	27.10	28.08	26.47	28.08	30.13
Unemployment Rate (%)	6.48	6.36	6.48	5.27	6.48	5.50

Note: This table displays the pre-treatment predictor balance for the analysis of alcohol sales. The difference in the value of the predictors is minimized using synthetic control method. The predictors include the number of drinks consumed for different types of alcohol (wine, beer, spirit) from 2006 to 2010, median age for males and females, per capita income, marriage rate, percentage of individuals with bachelor's and high school degrees, and unemployment rate. For the three types of beverage, the pre-treatment consumption appear to closely align between the treated and synthetic control groups, indicating a strong balance. There is a notable difference in per capita income, which stands out as somewhat divergent.

Table A2: Unit Weights Assigned to Each State for Beer, Spirit, and Wine Sales Analysis

State	**Wine**	**Beer**	**Spirit**
Alabama	0.007	0	0.015
Alaska	0.018	0.019	0.007
Arizona	0.011	0	0.015
Arkansas	0.005	0.055	0.015
California	0.005	0	0.017
Colorado	0.028	0	0.015
Delaware	0.089	0.113	0.016
District of Columbia	0.185	0	0.014
Florida	0.009	0	0.021
Georgia	0.006	0	0.016
Hawaii	0.017	0	0.028
Idaho	0.08	0	0.016
Indiana	0.007	0	0.017
Iowa	0.005	0	0.014
Kansas	0.004	0	0.016
Kentucky	0.005	0	0.015
Louisiana	0.007	0	0.013
Maine	0.009	0	0.018
Maryland	0.028	0.302	0.021
Massachusetts	0.014	0	0.019
Michigan	0.009	0	0.015
Minnesota	0.005	0	0.010
Mississippi	0.005	0	0.014
Missouri	0.02	0	0.012
Montana	0.01	0	0.015
Nebraska	0.006	0	0.014
Nevada	0.108	0	0.063
New Hampshire	0.024	0	0.008
New Mexico	0.007	0	0.017
North Dakota	0.008	0	0.020
Ohio	0.005	0	0.015
Oklahoma	0.005	0	0.015
Oregon	0.01	0	0.015
Pennsylvania	0.009	0	0.014
South Carolina	0.006	0	0.016
South Dakota	0.029	0	0.306
Texas	0.008	0	0.015
Utah	0.006	0.511	0.013
Vermont	0.016	0	0.016
Virginia	0.149	0	0.017
West Virginia	0.004	0	0.014
Wisconsin	0.008	0	0.012
Wyoming	0.006	0	0.014
Total	**1.000**	**1.000**	**1.000**

B. Appendix: Replication Study

In this section, we replicate the main result of Gehrsitz (2021) to confirm the robustness of the NIAAA Alcoholic Beverage Sales dataset used in our analysis.

Gehrsitz's study is a cornerstone in revealing the effect of tax policies on alcohol consumption through causal experimental design. He leverages a natural experiment in Illinois in 2009, where spirits and wine taxes rose sharply while beer taxes saw only minimal changes. The spirits excise tax nearly doubled, rising from \$4.50 to \$8.55 per gallon, while the wine tax also nearly doubled, increasing from \$0.73 to \$1.39 per gallon. In contrast, beer taxes experienced a negligible increase of just 4 cents per gallon.

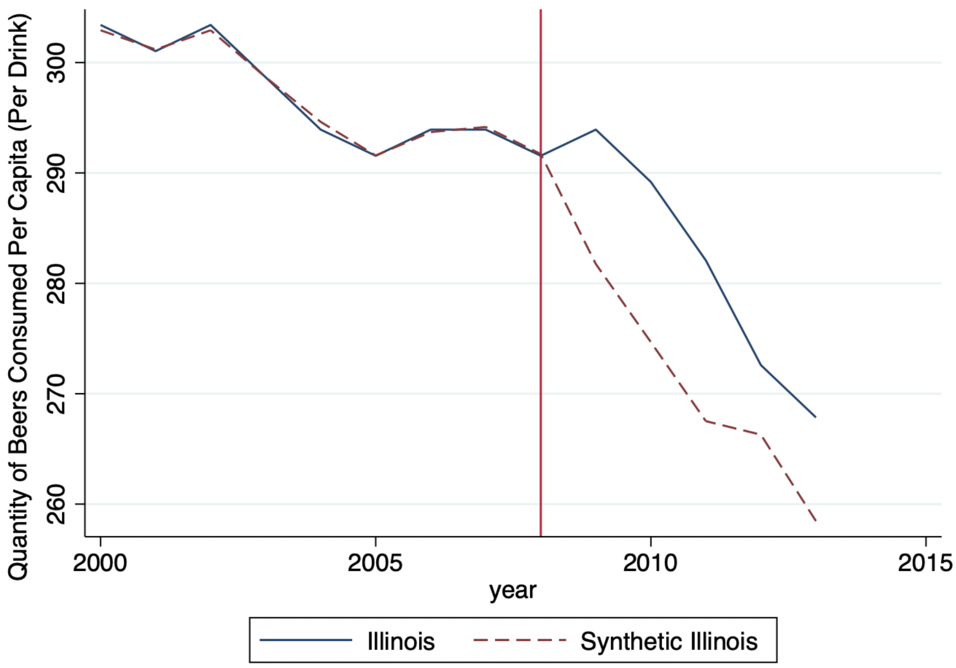
By analyzing Nielsen IQ Scanner data from various alcoholic beverages across thousands of stores nationwide, Gehrsitz constructs comprehensive measures of alcohol prices and sales. His analysis, based on difference-in-differences models, reveals an immediate over-shift in alcohol excise taxes: a \$1 tax increase translates into price hikes of up to \$1.50. Gehrsitz finds evidence that consumers respond by opting for cheaper alternatives, particularly increasing beer purchases, thus mitigating the potential reduction in overall ethanol consumption due to taxes.

The main result of Gehrsitz's paper is that consumers engaged in cross-product substitutions, with an increase in beer consumption by about 4.0% in the year following the increase in taxes. We replicate this result using the Alcoholic Beverages Sales data sourced from the NIAAA 34th surveillance report, which details per capita alcohol consumption in the United States (Slater and Alpert, 2020). We follow the same method as Gehrsitz (2021), specifically a difference-in-differences model and use the synthetic control method to replicate the analysis. The Table B2 outlines the weights selection for the synthetic control group, while Table B3 demonstrates the balance of predictors, revealing close similarity between the treatment and control groups during the pre-treatment period.

The Figure B1 depicts the relative increase in beer consumption in Illinois, following the implementation of the tax increase on wine and spirits in 2009. We find that this increase in beer consumption is highly significant after the increase in taxes, as revealed by Table B1. Beer increased by 12.18 drinks per capita (+4.14%) immediately after the increase in taxes. The magnitude of the increase in consumption is comparable to Gehrsitz's increase of "about 4.0%" in the year following the increase in taxes. Although Gehrsitz does not delve into sales beyond 2011, our extended analysis confirms that this surge in beer consumption stays significant for as long as two years after the tax adjustment. Notably, the rise in beer consumption shows considerable significance in both 2010 (by 5.02%) and 2011 (by 5.04%) when juxtaposed with the post-taxation baseline.

This replication of Gehrsitz's findings using the NIAAA Alcoholic Beverage Sales dataset confirms the robustness of the dataset employed in our analysis. This consistency across analyses reinforces the confidence in drawing conclusions regarding the effects of tax policies on alcohol consumption patterns using NIAAA data.

Figure B1: Evolution of the quantity of beer consumed per capita from 2000 to 2013



Note: This graph illustrates the change in the quantity of beers consumed per capita from 2000 to 2013 in Illinois and in the control group. Upon visual inspection, the graph reveals a relative increase in beer consumption following the implementation of the tax increase on wine and spirits, effective September 2009.

Table B1: Change in Beer Consumption Per Capita in Illinois

Year	**Estimates**	**% change**	**P-Value**
2009	12.18***	4.14***	0.00
2010	14.51*	5.02*	0.02
2011	14.56***	5.04***	0.00
2012	6.30	2.18	0.08
2013	9.39	3.25	0.05

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: This table presents the estimates of changes in beer consumption and p-values following the alcohol tax increase in 2009. Overall, the table reveals a 4.14% increase in beer consumption immediately after Illinois' tax hike on wine and spirits. While Gehrsitz (2021) does not examine sales after 2011, we extend the analysis and demonstrate that this increase in beer consumption remains significant for up to 2 years following the tax increase. Indeed, the change in beer consumption is highly significant in 2010 (+5.02%) and 2011 (+5.04%) compared to the post-treatment baseline.

Table B2: Unit Weights Assigned to Each State for Gehrsitz (2021) Replication Analysis

State	**Weight**
Alabama	0
Arizona	0.102
Arkansas	0
California	0
Colorado	0.007
District of Columbia	0
Florida	0
Georgia	0
Hawaii	0
Idaho	0
Indiana	0
Iowa	0
Kansas	0.131
Kentucky	0
Maine	0
Maryland	0.373
Massachusetts	0
Michigan	0
Minnesota	0
Mississippi	0
Montana	0
New Hampshire	0
New Mexico	0.001
North Dakota	0
Ohio	0
Oklahoma	0
Oregon	0
Pennsylvania	0
South Carolina	0.133
South Dakota	0
Texas	0.134
Vermont	0
Virginia	0
West Virginia	0
Wisconsin	0.072
Wyoming	0.047
Total	**1.000**

Note: This table presents the weights selection for the synthetic control group. The synthetic control group to Illinois is composed of states such as Maryland (37.3%), Texas (13.4%), Kansas (13.1%), South Carolina (13.3%), Wisconsin (7.2%), Arizona (10.2%), Colorado (0.7%), Wyoming (4.7%), and New Mexico (0.1%).

Table B3: Pre-treatment Predictors Balance for the Alcohol Sales Analysis

Predictors	**Treated**	**Synthetic**
Alcohol values		
Number of Beers (2001)	301.03	301.18
Number of Beers (2002)	303.41	302.92
Number of Beers (2003)	298.67	298.67
Number of Beers (2004)	293.92	294.62
Number of Beers (2005)	291.55	291.58
Number of Beers (2006)	293.92	293.70
Number of Beers (2007)	293.92	294.16
Number of Beers (2008)	291.55	291.70
Controls		
Median Age Male	34.5	35.1
Median Age Female	37.23	37.75
Per Capita Income ($)	27,804	27,873
Marriage Rate (%)	51.2	52.8
Bachelor's Degree (%)	18.39	17.83
High School Degree (%)	28.45	28.56
Unemployment Rate (%)	5.4	4.6

Note: This table presents the estimates of changes in beer consumption and p-values following the alcohol tax increase in 2009. Overall, the table reveals a 4.14% increase in beer consumption immediately after Illinois' tax hike on wine and spirits. While Gehrsitz (2021) does not examine sales after 2011, we extend the analysis and demonstrate that this increase in beer consumption remains significant for up to 2 years following the tax increase. Indeed, the change in beer consumption is highly significant in 2010 (+5.02%) and 2011 (+5.04%) compared to the post-treatment baseline.