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Compliment or Substitute? Impact of Marijuana Legalization on Alcohol Consumption

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By

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Abstract

This paper uses a state-level alcohol sales dataset to analyze how marijuana legalization affects alcohol consumption. I employ a difference-in-differences model to investigate the relationship between alcohol and marijuana in the short-term and long-term. In addition, marijuana legalization effects are estimated for different alcohol types – beer, wine and spirits. Overall, the results indicate a negative, yet insignificant relationship between the two narcotic drugs. There is not enough evidence to firmly conclude substitutability or complementarity of the two goods, therefore, leaving the debate unsolved.

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1. Introduction

In August of 2018, an investment decision from Constellation Brands (STZ) shocked the financial world.[1] Their investment of $4 billion into Canopy Growth Corporation (CGC) will be remembered as one of the boldest and unpredictable decisions in the history of the alcohol industry.[2] The company paid an unanticipated and large premium (20%) for CGC shares. In terms of technical equity investment, the purchase left a lot of analysts questioning the investment decision because STZ significantly overvalued CGC.[3] An explanation for this strategic move is that the STZ board has a very optimistic outlook towards CGC and the industry of marijuana in Canada, the United States, and the world. STZ, a major producer of alcohol, is anticipating further changes in marijuana regulation which would imply a new market opening. STZ's viewpoint is not unprecedented because further state and, eventually, federal marijuana legalization in the United States could have second order effects on alcohol consumption which could heavily affect STZ's bottom line.

Over the past 20 years, changes in government policy towards marijuana have resulted in 10 US states having legalized recreational marijuana and 33 states having legalized medicinal marijuana (Coit, 2018). As legalization efforts are gaining traction, researchers and policy makers argue about the advantages and shortcomings of legal marijuana.[4] Previous literature finds significant spillover results in other industries like real estate and healthcare (Zhang et al., 2017; Cheng et al., 2018; Powell et al., 2018; Bradford and Bradford, 2018), but one of the key discussion

[1] Producer of alcoholic beverages like Corona, Modelo, Svedka and Napa Valley etc.
[2] Retrieved from https://www.cbrands.com/news/articles/constellation-brands-5-billion-cad-4-billion-usd-investment-in-canopy-growth-closes-following-shareholder-and-canadian-government-approval Access date: 4/6/2019
[3] Retrieved from https://seekingalpha.com/article/4234662-constellation-brands-canopy-growth-paying-excellent-purchase-horrible-price Access date: 4/6/2019
[4] Canada legalized recreational marijuana in the fall of 2018.

points, that is of utmost importance specifically for STZ, is the relationship between the two narcotic substances – marijuana and alcohol.

Based on basic economic theory, two normal goods (marijuana and alcohol) can act either as substitutes or complements. In other words, increased access to one good (in this instance - legalization) could either negatively or positively affect the consumption of the other good (Caulkins et al. 2016). The nature of the drugs and its effects on overdose is what makes this a vital topic (Caulkins et al. 2016). As more states legalize marijuana, it is important to understand the natural effect full decriminalization could have on alcohol consumption. There is a substantial amount of literature analyzing this relationship. Studies such as Williams (2004) and Gunn et al. (2018) find that alcohol consumption is positively related to marijuana legalization. Some authors also state that marijuana is a gateway drug to alcohol (Asarkaya 2010), and that marijuana and alcohol are complements (Wen et al., 2015). The opposition advocates for the substitutability between the two goods (Anderson et al., 2013; Baggio, 2017; Dragone et al., 2018; Miller and Seo, 2019) while reviews of the whole body of literature portray an ambiguous and unpredictable relationship (Subbaraman, 2014; Guttmannova et al., 2016). The aim of this study is to help settle the debate and find evidence for substitutability or complementarity. My hypothesis is that there is a significant relationship between the two goods.

By employing a difference-in-differences (DID) model and accounting for time-invariant state fixed effects, I estimate the effect of medicinal and recreational marijuana legalization on alcohol consumption. My contribution to the literature is the isolation of recreational marijuana from medicinal marijuana legalization. I also add to the literature by testing different alcohol categories independently, with the anticipation of discovering heterogeneity. In addition to the short-term estimations, as presented by Dragone et al. (2018), I add a test of long-term effects for

my control and treatment states since previous authors (Dragone et al., 2018; Baggio, 2017) do not find or fail to look for long-term effects.

My findings suggest a negative, yet statistically insignificant relationship between marijuana and alcohol. States that have legalized either medicinal or recreational marijuana have relatively lower levels of alcohol consumption. Specifically, legalization of medicinal marijuana in the long-term decreases "all drinks" consumption by 0.276 gallons of ethanol per capita (Table 6, Column 4). Legalization of recreational marijuana in the long-term decreases "all drinks" consumption by 0.557 gallons of ethanol (Table 8). However, the results are mostly insignificant and not robust. Additionally, the short-term and long-term estimations' results do not differ that much. In general, beer consumption seems to have the most robust results while wine magnitude was minimal.

The rest of this paper is structured as follows: section 2 provides marijuana legalization background and an in-depth review of the studies related to its effect on alcohol consumption. Sections 3 and 4 describe the data and the model that are used to estimate the effects of marijuana legalization. Section 5 interprets the findings, while section 6 discusses the limitations and policy implications of my study. Concluding remarks are presented in section 7.

2. Literature Review

2.1 Overview of Marijuana Legalization

In 1937, the Marijuana Tax Act was passed in the U.S., and it was the first official attempt by Congress to regulate marijuana. Although production was not prohibited explicitly, sale and possession of marijuana were made illegal (Coit, 2018). The Controlled Substances Act (CSA), passed in 1970, treated marijuana as a Schedule 1 drug – any use of the substance was deemed illicit (Coit, 2018). This act signified the beginning of the war on drugs, which was only intensified

by the Reagan administration. The last decades of the 20th century witnessed aggressive policy enforcements against marijuana such as police raids, surveillance and others (Vitiello and Deck, 2018). Illegal, but a very profitable business led to the establishment of drug cartels, which became the main source of illegal marijuana. Drug cartels used violence and aggression to fight against the law instead of peaceful negotiations with the government. That is one of the reasons why reforms of marijuana legalization were slow and practically unabundant (Vitiello and Deck, 2018). In recent years, however, the federal administration has changed its view on marijuana laws. Government officials noticed that violence and crime rate in this industry had started rising rapidly, and, thus, considered decriminalizing marijuana. Plus, legalizing marijuana has potential benefits like the broadening of the tax base, creating job spots, and diversifying the economy (Vitiello and Deck, 2018). Thus, after many efforts towards decriminalization of marijuana, California became the first state to legalize medical marijuana in 1996 (Vitiello and Deck, 2018). Nonetheless, prosecution of illegal marijuana was still aggressive until former President Barack Obama enforced a more lenient approach towards facilities and allowed states to experiment with medicinal and recreational marijuana (Vitiello and Deck, 2018). Washington and Colorado were the frontrunners in the efforts to insert recreational marijuana's legalization into the voting ballots during presidential elections. Federal government did not respond harshly to the 2012 marijuana propositions from Washington and Colorado, signifying the beginning of legalization efforts across the nation (Vitiello and Deck, 2018). Especially after the passing of the Farm Bill of 2018 and clarification of regulations of hemp, a cannabis plant that produces marijuana, momentum has accumulated toward the federal legalization of marijuana (Coit, 2018). As of today, ten states have legalized recreational marijuana and 33 states have legalized medicinal marijuana. It is important

not to use medicinal and recreational marijuana interchangeably. The distinction between the two types of marijuana will be discussed in the following sections.

2.2 Medicinal & Recreational Marijuana

Marijuana is the most popular illegal drug in the United States.[5] The drug itself is dried leaves, and stems from *cannabis sativa* and its primary components are tetrahydrocannabinol (THC) and cannabidiol (CBD).[6] Marijuana, in general, over-activates parts of the brain, induces a "high" feeling and numbs pain.[6] The main difference between medicinal and recreational marijuana is ratio of THC and CBD in the substance.[6] Medicinal marijuana mostly has CBD which does not have any psychoactive effects except for numbing pain, whereas recreational marijuana is mostly comprised of THC, which induces the "high" feeling. Medicinal marijuana is strictly tested and measured to meet the health standards, whereas recreational marijuana is not monitored. Gaining access to each of the marijuana types differs strictly, as well. To buy medicinal marijuana, contrary to recreational marijuana, one typically must own a "recommendation" from an approved physician. The recommendation must be reapproved regularly; however, once prescribed, one can get it at any licensed medicinal marijuana dispensary.[7] States that have legalized recreational marijuana have an abundance of cannabis shops and dispensaries in which the marijuana consumers are able to access the drug without any prescription or recommendation. Thus, there are significant differences between recreational and medicinal marijuana, and it is paramount not to confuse the state laws and potential legalization implications of these substances.

2.3 Health Impacts

[5] Retrieved from https://www.samhsa.gov/data/sites/default/files/NSDUH-DetTabs-2015/NSDUH-DetTabs-2015/NSDUH-DetTabs-2015.pdf Access date: 4/3/2019
[6] Retrieved from https://www.drugabuse.gov/publications/drugfacts/marijuana Access date: 4/3/2019
[7] Retreived from http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx: Access date: 4/3/2019

There is a substantial amount of research and evidence pointing toward medicinal marijuana's effectiveness for patients dealing with chronic pain, nausea during chemotherapy, multiple sclerosis symptoms, and many others.[8] While the medical benefit of marijuana is undeniable, opponents of marijuana legalization worry about the increasing adolescent marijuana use, young teen and children exposure to marijuana and, especially, second hand smoke (Schuermeyer, 2014). Usually, marijuana's effects last only from 30 minutes to an hour; however, prolonged use of marijuana, especially in the developing stages of a person's brain, could lead to long-term cognitive shortcomings.[9] Legalizing recreational marijuana allows access for people to use it as they please. These consumers do not necessarily need marijuana for medical purposes; they might consume it for relaxation purposes. Increases in marijuana consumption might have other side effects, which are uncontrollable. Lab studies found that marijuana second hand smoke might be more harmful than tobacco second hand smoke (Vitiello and Deck, 2018). As years pass, more data is going to be available on marijuana consumption and its direct as well as indirect effects on people. Research is needed to look at the big picture and weigh all the pros and cons of marijuana legalization.

2.4 Alcohol Consumption

One indirect effect of marijuana is on alcohol consumption. Legalization scholars researching legalization stated that easier access to marijuana influences alcohol consumption. Sen et al. (2002) propose that marijuana is a gateway drug to alcohol and other addictive substances. Others mentioned that marijuana is a complementary good to alcohol, meaning that as consumption of marijuana increases, so does alcohol consumption (Asarkaya, 2010). Increased

[8] Retrieved from https://www.nap.edu/read/24625/chapter/2#8 Access date: 4/3/2019
[9] Retrieved from https://www.drugabuse.gov/publications/drugfacts/marijuana#ref Access date: 4/3/2019

consumption of alcohol implies more deaths from overdose, fatalities while driving under influence (DUI), and more crime (Asarkaya, 2010). The opposition (Anderson et al., 2013; Baggio, 2017; Dragone et al., 2018) found that marijuana legalization negatively affects consumption of alcohol. There is a vast amount of literature discussing the relationship between marijuana and alcohol consumption; however, researchers cannot come to a consensus on the debate about marijuana and alcohol complementarity and substitutability (Subbaraman, 2014; Guttmannova et al., 2016). Literature reviews stated that the results heavily depend on the complexity, location, demographics and the model of the analysis (Subbaraman, 2014; Guttmannova et al., 2016). According to the authors, more research with better data is needed to answer the question more accurately. The following section presents arguments in the literature for each of the opposing sides.

2.5 Evidence on Complementarity

Williams (2004) used a cross-price effects model to investigate the relationship between the demands of alcohol and marijuana for college students. In the probability (probit) model built with dichotomous indicators, the author included non-monetary components such as accessibility and legal environment. Data was collected at three points in time (1993, 1997 and 1999). 200 students from 140 colleges nationwide sent in anonymous surveys resulting in over 17,000 student study participants. Important to note is that the authors collected the self-reported amount of alcohol consumed, however, they did not do the same for marijuana's consumption. They relied only on the self-reported participation (last week, last month, and last year) decisions to complete their analysis. Thus, the amount of substances used was omitted from the analysis. The authors obtained marijuana prices from the Illegal Drug Price/Purity Report, which reported minimum and maximum price for 19 cities in 16 states. The authors used proxies to control for the

decriminalization and included the full price of using the substance such as the opportunity cost of drinking beer or a fine for possessing marijuana. The authors controlled for alcohol access by introducing dummy variables like “greater than one bar within one-mile radius to the school”, “alcohol free dorms are available on campus” or “complete alcohol ban on campus”. It was found that an increase of perceived price of marijuana decreased the use of both goods, and policies that reduced access to alcohol consumption reduced both alcohol and marijuana use. The authors found that price elasticity for marijuana participation was –0.24, indicating an inverse relationship between quantity of alcohol consumed and the cost of using marijuana. According to the findings, the lower the cost of consuming marijuana, the higher quantity of alcohol consumed. Nevertheless, it is important to look at the way the authors estimated the total cost of using marijuana. They included possible legal sanctions, fines and a several other of other opportunity costs with marijuana consumption, which in the end appeared to not have a statistically significant impact on the analysis. As expected, schools that strictly prohibit use of alcohol on campus had a significantly lower participation in marijuana. Controversially, their second measure for alcohol access (distance from campus to bars) had a negative and significant impact on alcohol use, however, no significant relation to marijuana use was found. The authors’ conclusion of complementarity was based on the campus alcohol bans and lower marijuana participation rates in those instances.

The first limitation of the study was the validity of students’ responses about marijuana consumption. Even though they were anonymous, it is very unlikely that students completely trusted examiners and were honest about their alcohol and marijuana consumption habits, especially in the instances where using the substances was illegal. Logically thinking, the survey data must have been skewed because the likelihood that respondents were not underreporting their marijuana usage was very low. Also, the control variable of alcohol ban on campuses seems

questionable. Lower consumption of marijuana on conservative campuses could have resulted from schools having strict policies on alcohol consumption which does not attract students who would have been subject to using any substances. It makes more sense when the other control variable, amount of alcohol selling places within one-mile radius from the school, is considered. If marijuana and alcohol are complements, one would expect that the smaller amount of alcohol vendors, the lower the alcohol consumption. Therefore, the lower the alcohol consumption, the lower marijuana consumption. The authors could not find evidence for this phenomenon. The authors were only able to get 19 city (19 DEA offices) prices for marijuana whereas their survey responses from schools were nationwide. The authors had to assume a linear relationship between the distance of the school and the DEA office and the price of marijuana. Finally, the proxy of decriminalization and the opportunity cost truly assumed that people think in economic terms while making decisions for consumption which may not be realistic. Overall, the study had to make a lot of questionable assumptions to come to final conclusions about the complementarity of the substances.

Another study that explored college students' self-reported substance abuse was conducted by Gunn et al. (2018) in which they used 488 student responses on alcohol and marijuana usage in their first 2 years of college experience. Those assessments were bi-weekly and tracked the same students over their first two years of college. The assessments asked whether the subjects had used alcohol and/or marijuana in the past two weeks, how much, and if they had experienced any of negative alcohol related consequences. The authors conducted a series of linear mixed models. “Mixed” model denotes the fact that both, random and fixed effects, are incorporated in the linear predictor. The researchers concluded that consistent marijuana consumption was positively related to daily alcohol consumption. More specifically, on days that marijuana was used, students self-

reported to have had more drinks and higher blood alcohol level, thus indicating the complementarity of the substances (Gunn et al., 2018).

The authors acknowledged that their study pertains several limitations. Firstly, data was self-reported, and the participants could have completed the assessment just for the compensation. Also, the authors only asked about "smoking" of marijuana, whereas it could be consumed in other ways. Self-reporting blood alcohol level and negative consequences after consuming alcohol is a subjective data point, which skews the data of the study. The authors had wished they could have extended the study for a longer time to get clearer results. Interesting to note is that the participants who were included in the study had reported to have had at least one drink. It would be interesting to apply this study method to marijuana legalization timeline to estimate marijuana and alcohol co-use adoption. Overall, Gunn et al. (2018) claimed that students' use of marijuana is positively related to alcohol consumption.

Wen et al. (2015) explored the relationship between medical marijuana legalization and other substance consumption. The authors used National Survey on Drug and Health (NSDUH) data to calculate marijuana, other opioid use and binge drinking. A two-way fixed effects model with state-specific linear time trends and a rich set of individual- and state-level covariates that had data from ten states (2004-2012) was employed in the analysis (Wen et al., 2015). The authors controlled for state-varying unemployment rate, average personal income, and median household income of the state, accompanied by decriminalization and beer tax changes within the state. Effects of marijuana legalization were estimated for teenagers (12-20) and adults (21 and over) to portray the impact of underage drinking. The authors found that medicinal marijuana legalization led to heavier consumption of marijuana (Wen et al., 2015). In addition, no significant differences were found in the number of drinks, however, legalization of marijuana resulted in more high-dose

alcohol drinking for adults, possibly for both substances being used together (Wen et al., 2015). Such findings indicate that marijuana legalization has positive effects on binge drinking, although regular consumption of alcohol could be affected in the opposite way.

The major limitation of the study is the reliability of the NSDUH dataset, since it is a survey. Some of the states covered in the survey have marijuana consumption data before it was legal in the state, therefore, the dataset is a rough estimation. Also, binge drinking data collection (number of days of heavy drinking) is vague with no clear definition of how binge drinking should be interpreted. NSDUH data is always an average of 2 years, therefore, the dataset is the major limitation of the study. Since data is so limited, it is helpful to rely on other factors, such as driving under influence or crime rates, which are very closely tied to alcohol, to estimate the effect marijuana legalization has on alcohol consumption.

Overall the body of literature advocating for complementarity of marijuana and alcohol displayed significant results, however, the data and models that were used underrepresented the real economic effects in the instance of marijuana legalization. In other words, authors had to use questionable assumptions in order to simulate the real world. Survey based data is a limitation for the authors. It prevented authors from finding undeniable evidence to support their arguments. Survey data has to be evaluated with a grain of salt, especially when dealing with substances like marijuana, which are illegal (at the time of the study), and alcohol, which can induce self-consciousness feelings for respondents. Instead, I chose to use state-level data that describes alcohol consumption levels. I also use a DID model, which takes account of the time-invariant state-level features. Details about my model and data can be found in sections 3 and 4. The aim was to select a methodology for my estimation so that I do not have to include multiple assumptions to account for unmeasured differences between the states.

2.6 Evidence on Substitutability

Since there is evidence of complementarity of alcohol and marijuana, it is reasonable to think that legalization of marijuana leads to increased consumption of alcohol (a second order effect) which, in turn, causes more DUI fatalities (a third order effect). Such a hypothesis was tested using FARS data from 1990-2010 to estimate the effect of marijuana legalization on traffic fatalities (Anderson et al., 2013). The authors constructed a state level ordinary least square regression analysis in which they estimated medicinal marijuana laws (independent variable) effect on total fatalities (dependent variable), controlled by exogenous variables. The results of the regression analysis showed a 10.4% decrease in traffic fatalities immediately after legalization. However, when the authors included state-specific linear time trends, the results were no longer significant. Overall, the authors found significance in decrease of alcohol related deaths, and no significance in decrease of non-alcohol related deaths (Anderson et al., 2013). The authors disproved marijuana and alcohol complementarity (easier access to marijuana, more alcohol consumption, and more DUI accidents) by portraying a significant decrease in traffic fatalities.

The authors mentioned in their estimations that other, more difficult to measure laws could have impacted the legalization effect on the treatment states. Thus, they additionally include an analysis of alcohol sales and find that during the same period, treatment states had significantly lower alcohol sales levels. Based on this paper, I use alcohol sales data in my project. However, to argue that marijuana and alcohol are substitutes, long-term results are needed. Anderson et al. (2013) found no significant differences between the control and the treatment states four years after the legalization. The idea of convergence to status quo after two or more years is an interesting and important factor that needs to be assessed because it is very likely that marijuana legalization

creates a temporary herd mentality effect which lasts for a couple of years as the news spread around the states that pass the medicinal marijuana laws.[10]

Baggio (2017) also encountered evidence of cyclicality and convergence when comparing long term alcohol sales. The author used a DID estimation for total alcohol sales between states that have passed and states that have not passed medicinal marijuana laws during a specific period. Interestingly, alcohol consumption was measured by store sales in over 2,000 US counties. The author's intent in doing that was to take away the ambiguity of data from self-reported surveys of consumed of alcohol per capita. It is important to note that Baggio (2017) used medicinal marijuana legalization instead of recreational marijuana legalization. Medical marijuana usage is stricter than recreational marijuana, but, even though access is limited, as discussed in the previous section, it is hard to capture the availability and consumption from an economic standpoint. In other words, the effect of marijuana consumption on alcohol consumption in states with legal medicinal marijuana might have been skewed since a black market for marijuana still exists. The author accounted for the timing of the legislation and included detailed provisions of the law as time went on and added regression models to see the effect of each of the four specific provisions. In addition, the author included control variables such as median household income, unemployment level, race, gender, and age breakdown. I use the Baggio (2017) methodology in my analysis, particularly the DID model. I additionally include an estimation of recreational legalization, which separates the convolution between medicinal and recreational marijuana legalization.

[10] The foreshadowed legalization expectations and inadvertent advertisements about marijuana create a higher increase in demand than usual. Word of mouth advertising, about the legalization of marijuana creates the effect of herd mentality which later on dies down.

Baggio (2017) found that passing medicinal marijuana laws led to decrease in aggregate alcohol sales by around 15% and concluded that alcohol and marijuana are substitute goods. Nevertheless, when examining the short-term and long-term effects, evidence of cyclicality, and convergence of alcohol sales was found 2 years after enacting the medicinal marijuana laws in control and treatment counties. Since this paper fails to find long-term effects of the legalization, it serves as an incentive to include my long-term estimation which will be discussed in section 4.

The authors admitted that the size of the sample was one of the major limitations in their study to estimate concrete long-term effects. Another explanation is the already mentioned herd mentality effect. If, in fact, the two substances are substitutes, short-term and long-term effects should be both significant. The popularity and the trend to try legal marijuana might have been the main cause of the short-term sharp decrease in aggregate alcohol sales. People could have reallocated their disposable income that usually goes to alcohol toward marijuana since it is the "new product". The effect of anticipation is a possible explanation for the absence of significant results in the long-term. Before a bill, legalizing marijuana gets passed, there could have been rumors that marijuana will be legalized, thus, creating inadvertent advertising and anticipation of the substance entering the market. Once the substance became legal, people might have switched to the long-awaited marijuana for the short-term, while going back to their usual consumption patterns in the long-term. I suspect that the phenomenon of cyclicality might have also occurred because of the possibility of cross-border transportation of marijuana. Control and treatment counties were cross-state neighboring counties. In regards of economic theory, it helps to have cross-state neighboring counties that have different state laws because that means the sample population living in those counties is the very much alike. However, the fact that they are so close to each other might indicate the risk of illegal transportation to the black market in the long-term.

Drug markets in the bordering state counties might have needed some time to set up systems through which supply of illegal marijuana could be increased, thus eliminating the second order effect on alcohol sales in the long-term.

Another attempt to capture the effect of marijuana legalization on alcohol consumption was made by Dragone et al. (2018). There is a popular notion that marijuana leads to more crime, and, especially, legalizing it would have an additional negative effect. Alcohol makes people more aggressive, more violent, therefore, legalization of a complementary good to alcohol should yield higher crime results. Dragone et al. (2018) employed a DID analysis coupled with spatial regression discontinuity (SRD) in order to address the effects of recreational marijuana legalization in Washington and Oregon. My analysis uses a simplified version of Dragone et al. (2018) model. The authors used Uniform Crime Reporting (UCR) data for years 2010 to 2014 to estimate changes in crimes against people or property. The dataset had 335 observations in 75 counties bordering Oregon and Washington. They also employed the already mentioned NSDUH data to calculate changes in consumption of substances. The dependent variable was crime rates after the recreational marijuana laws were passed in Washington in 2012. They compared the change of crime rates in Washington (treatment) pre- and post-enactment of the bill to the change in crime rates in Oregon (control) pre- and post-enactment of the bill. Spatial regression discontinuity means that the border counties of each of the states are demographically alike since they are so close, however, they experience a change in marijuana laws (treatment effect). A quasi-experiment design is applied to this study which allows to establish causality. The authors argued that timeline of the laws fitted perfectly because Washington and Oregon populations are very similar; when Washington passed the recreational marijuana law, Oregon failed to do it by a slim margin.

Therefore, having a two-year window between legalizations in each of the states provides an opportunity for a DID estimation (Dragone et al., 2018).

The authors found that after recreational marijuana legalization in Washington, rape, property crime and theft decreased significantly when compared to Oregon. Important to note is that there were no differences before the implementation of the law between the two states, and it only appeared after the treatment. They also found robust results from substance abuse analysis. Post treatment, Washington counties' consumption of marijuana significantly increase, while the consumption of other drugs and alcohol significantly decreased (Dragone et al. 2018). The authors effectively linked their results and provided four different ways recreational marijuana legalization might have affected crime. Firstly, marijuana is a relaxing, euphoric drug which could make people less violent. Secondly, substituting other drugs or alcohol with marijuana which relaxes people might have helped to prevent crime as well. Thirdly, legalization of marijuana might have helped the police to shift their efforts from capturing illegal marijuana dealers to prevent other offenses from happening. Lastly, people that had been involved in illegal markets of marijuana were no longer prosecuted and their gang role was reduced, pushing them out of the market.

The effect of cross-border spillover effect is mentioned, but not explicitly and not enough time is dedicated to this possible limitation within the study. Since transportation between states is unrestricted, it is very likely that people from Oregon would import "legal" recreational marijuana into Oregon. The authors only stated that since this phenomenon has been proved by other researchers (Hao and Cowan, 2017), their estimates should be interpreted as "lower bounds of interest". Selecting states that fit a DID-SRD design is very clever; however, there is a need to take care of the transportation impact to the analyses. Oregon's drug cartels could have easily shifted their efforts from illegal recreational marijuana production and sales (which is not

mentioned in this study) to acquiring and transporting marijuana from Washington. Such a phenomenon would decrease crime rates in Washington and provide a supply boost of marijuana to Oregon, which provides a possibility of higher crime rates after the treatment. To comply with the SRD design, the authors could have chosen Idaho as the control state. Idaho completely prohibits the use of any marijuana. Some might say that Idaho is a very different state from Washington; however, on average, people living on the very border of both states should theoretically be demographically similar. Even if the people are drastically different in the two states, including Idaho as their additional test could shed some insights when compared with the Oregon test. The authors could have also compared Washington changes in crime to the changes in crime nationally or in other states that have lenient marijuana laws because a sample of 335 offenses might not be big enough. Plus, the imminent national marijuana legalization will have a long-term impact on the whole country, so states that are not that lenient to marijuana users will go through a drastic change. To do so, I include several states in my regression with the hopes of eliminating state-level differences and the effect of cross-border spillover. The purpose of DID is to capture the spatial differences between the control and the treatment group. The NSDUH data provides very questionable estimates since it's an average of 2 years and knowing the fact that the window between Oregon passing the recreational marijuana laws was 2 years implies that results must be interpreted with caution. In addition, the NSDUH data provides averages for the whole state, not for the border counties which were of interest to the authors. There also might be a lag in the shift of crime rates and substance use for Washington. This study only considered the relatively short-term impact of the change in policy. It would be interesting to explore long-term effects for crime and substance use (herd mentality effect). My study includes a long-term (5 year) estimation and including such a technique in this study (where the control group does not legalize

marijuana after 2 years) would have answered the question of cyclicality and the effect of anticipation or herd mentality. Overall, Dragone et al. (2018) methodology serves as a foundation of my experimental design to which I add more treatment and control states as well as a long-term estimation of the marijuana legalization initiatives.

Another way to observe indirect alcohol consumption is through taxes. If marijuana and alcohol were complements, states that legalize marijuana should not see any negative changes to alcohol tax revenues. Therefore, state panel scanner data was used to estimate the effect of marijuana legalization (Miller and Seo, 2019). The authors captured edibles, plant and concentrate measures for marijuana; beer, wine and liquor for alcohol; and an additional estimation of cigarettes and other tobacco products. They constructed a flexible cross-price elasticity model across substance and across categories of substance. The model was very similar to the already mentioned Anderson et al. (2013) study. County fixed effects were included to control for tastes, political views and evolution of the markets.

Overall, the authors found that 40% of tax revenue for marijuana came from decreases in tobacco and alcohol revenues (Miller and Seo, 2019). This article differs from other literature because it claims to be the first estimation of recreational marijuana legalization effect on other substances. One of the most interesting findings was that, even though Washington has the highest marijuana tax rates in the country (1%), it could still raise taxes and collect more in revenues. The study is very sophisticated which controls for state effects, price and taste differences.

The results from this section indicate substitutability, implying that the marijuana and alcohol industries are very closely negatively related, at least in the relative short-term. Two bodies of literature (sections 2.5 and 2.6) provide contradicting evidence while leaving no true answers about the relationship between the substances. Authors employed many assumptions which

complicate the simulation of the real world. Other second order effects of marijuana legalization include rising demand for real estate prices for warehouses in states that legalize marijuana (Zhang et al., 2017), causing an overall appreciation of the housing market (Cheng et al., 2018), decreasing number of deaths related to opioid overdose (Powell et al., 2018) and decreased Medicare spending on its enrollees by $165.2 million one year after the legalization of medicinal marijuana (Bradford and Bradford, 2018).

2.7 Alcohol Industry Implications

The recent Farm Bill of 2018 that legalized hemp production in the state of New York and the growing number of states that have voted on the legalization of marijuana clearly depicts the future of marijuana – legalization is quite imminent. If, indeed, advocates for substitutability of marijuana and alcohol are right, companies in the alcohol industry could be exposed to a severe demand plunge that would be cannibalized by marijuana producers. To cover for potential revenue losses, alcohol producers should invest in cannabis companies to hedge their positions. STZ's investment into CGC is one of the first attempts of an alcohol industry conglomerate to enter the just developing marijuana industry. Another option could be to create marijuana infused beverages and, thus, counter the shift in consumer demand.[11] Literature to date is portraying contradicting results when it comes to the relationship between marijuana legalization and alcohol consumption. Some studies find evidence of complementarity (Wen et al., 2015; Gunn et al., 2018; Asarkaya, 2010; Williams, 2004), while others argue for substitutability (Andersen et al., 2013; Baggio, 2017; Dragone et al., 2018). My attempt is to examine the relationship between those two substances and provide evidence to help settle the debate. If the overall relationship is

[11] Coca-Cola was in talks to enter a marijuana infused drinks business in the early fall of 2018, however, Coca-Cola eventually backed out of the potential deal. Retrieved from https://www.forbes.com/sites/korihale/2018/09/27/coca-cola-dipping-into-the-cannabis-infused-drink-market/#6b5306ae5e0e Access date: 4/30/2019

complementary, legalization of marijuana would result in increases of alcoholic beverage demand. If the substances are substitutes, legalization of marijuana would result in decreases of alcohol demand. Regardless of the true marijuana legalization effects on alcohol consumption, an emerging market of marijuana is a perfect opportunity for legal drug producers to capitalize on the inevitable legalization of the currently black market. The rate of partnerships between marijuana, tobacco and alcohol corporations is rising simply because of the interconnectedness of the substances.[12] Alcoholic beverage suppliers must rethink their strategies in the light of the changing culture and policies towards marijuana.

Literature conveys that there is significant evidence for both sides of the marijuana-alcohol relationship argument. However, the DID model is the best way to find causality of marijuana legalization and alcohol consumption (Subbaraman, 2014; Guttmannova et al., 2016). Previous attempts have failed to find significant results in the long-term (Baggio, 2017). If there is convergence of alcohol and marijuana consumption rates in the long-term, the short-term substitutability evidence cannot hold its ground as a true descriptor of the relationship between the substances (Dragone et al. 2018). Thus, my paper fills this gap in literature and analyzes the effects in the short- and long-term. Spillover effect is another phenomenon that diffuses the robustness of the analyses; therefore, I create an estimation in which long-term estimations would be examined, and spillover effect would be accounted for by estimating the effects on a multiple-state level. I also isolate medicinal marijuana legalization effects from recreational marijuana legalization effects since they are inherently different. Lastly, I look for marijuana legalization effects on specific alcohol categories (beer, wine and spirits). Miller and Seo (2019) looked at tax revenue

[12] Altria, the owner of tobacco giant Marlboro, invested $1.8 billion in a cannabis company Cronos. Retrieved from https://www.cnn.com/2018/12/07/investing/altria-cronos-investment-marijuana/index.html access date: 4/6/2019

differences between different types of alcohol, thus, I decided to do the same. The intent of searching for heterogeneity between the types of alcohol comes from the fact that some states are known for the popular beer breweries, while others - for their well-known wineries. The following section describes the specificities of my data and the methodology of the analysis.

3. Data

3.1 Alcohol Consumption Per Capita

To measure the effect of marijuana legalization, I use state-level alcohol sales data from National Institute on Alcohol Abuse and Alcoholism report (Haughwout and Slater, 2018; Kaplan, 2016). It was accessed from Inter-University Consortium for Political and Social Research (ICPSR). The dataset includes nationwide alcohol consumption per capita (people aged 14+) for years 1977-2016. The amount of alcohol consumed is reported by gallons of ethanol and number of drinks per person. Total ethanol consumption is also broken down into three different categories of alcohol: beer, wine and spirits. I decided to include different types of alcohol in the model with the expectation of heterogeneous results. Because some states are known for brewing beer and others are known for their wineries, the effect of marijuana legalization might disproportionally affect the consumption of different alcohol categories. I include state-level control variables such as median income per capita, educational attainment (percentage of people 25 years or older with a high school diploma), ratios for race, gender and age balance within the state.

3.2 Medicinal Marijuana Legalization

Table 1 depicts a timeline of marijuana legalization by US State. To isolate and test medicinal versus recreational marijuana legalization effects separately, the total alcohol consumption dataset was split into two subsamples. The reasoning behind the split is because of the already mentioned differences in acquiring process and psychological effects between the two

types of marijuana. I suspect that the magnitude of recreational marijuana legalization could be larger than that of medicinal legalization because a greater population is directly affected. Medicinal marijuana legalization initiatives that occurred in Alaska, Oregon and Washington in 1998 were selected as treatment events for the medicinal marijuana legalization estimation. To avoid sample treatment effect distortion, states that passed marijuana legalizing laws in the previous or following years to 1998 have been excluded. In other words, my control states were handpicked to make sure that prior to 1998 and five years after 1998 no marijuana legalization efforts took place. My control states are Arizona Idaho, Montana, New Mexico, Texas and Wyoming. Some states ended up legalizing marijuana six or more years after my treatment. Similar to the Dragone et al. (2018) methodology, it is important to select states that have similar outlooks toward marijuana legalization. Ideally, the only difference between states of interest is the marijuana law that is implemented. Geographic location and size of the state was also important in the selection of the sample states. I focused more on larger states that are in the mid-west and west regions. In addition to that, I graphed alcohol consumption trends (1977-2016) for all the states in my selected sample to make sure that the overall trend is relatively similar (Figure 1). Control states' alcohol consumption is in black whereas treatment states' is in green. The graph portrays that, per person, there was decrease in alcohol consumption nationwide until mid-90s and alcohol consumption has been slowly increasing since (Figure 1).

3.3 Recreational Marijuana Legalization

Colorado and Washington, which were the first US states to have legalized recreational marijuana in 2012, were selected as treatment states for the recreational marijuana legalization effect estimation. 2014 and 2016 legalization efforts were not considered because the most recent alcohol consumption data has not been published. With the latest wave of legalizations in 2018, as

of now there are ten states that have legalized recreational marijuana (including Washington D.C.), and 33 states that have legalized medicinal marijuana (including Washington D.C.).[13] Control state selection was, again, based on whether the state had recreational marijuana laws in place prior to 2012 and 5 years after the treatment year. Control states that had medicinal marijuana laws around that time were also excluded because the aim of the estimation was to find the effect of recreational marijuana legalization by itself. As discussed in the section above, there are significant differences between medicinal and recreational marijuana. To prevent the sample control states from eradicating the treatment effect, states that have legalized medicinal marijuana have been omitted. Similar to the medicinal marijuana dataset, the geographic location and size of the state were important characteristics. In addition, I graphed alcohol consumption trends (1977-2016) for all the sample states to assess the trend (Figure 2). Again, I made sure that all the outliers that did not follow the same trend, were omitted from my sample. Control states were Idaho, Kansas, Montana, Texas, Wisconsin and Wyoming. The trend for recreational marijuana legalization sample alcohol consumption corresponds with the trend of the medicinal marijuana legalization sample (Figures 1, 2).

Tables 2 and 3 present summary statistics for the variables of my analysis. Table 2 refers to the medicinal marijuana legalization dataset whereas Table 3 pertains summary statistics of the recreational marijuana legalization dataset. The first dataset has 18 (12 control and 6 treatment) observations, while the second dataset has 16 (12 control and 4 treatment) observations. State-level alcohol sales means between control and treatment groups do not portray substantial differences between the states. My dependent variables are consumption of gallons of ethanol in

[13] Retrieved from https://www.thestreet.com/lifestyle/health/states-with-legalized-marijuana-14581737 Access date: 4/4/2019

beer, wine, spirits and all drinks, respectively. Means between categories of alcohol vary, indicating that beer is the most popular type of alcohol followed by spirits and wine.[14] Standard deviations are small and consistent across the different datasets. Previously discussed independent variables (descriptive statistics) are summarized in Tables 2 and 3, as well. On average, sample states are mostly white (75.5% in the medicinal dataset, 87.5% in the recreational dataset), equally distributed by gender (50% male), most of the people have a high school diploma (83.6% in the medicinal dataset, 89.6% in the recreational dataset) and are mostly older than 20 (69.5% in the medicinal dataset, 72.8% in the recreational dataset).

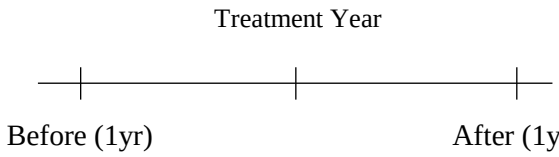
4. Model

4.1 Difference-in-differences (DID) Model

I developed my model based on the Dragone et al.' (2018) methodology. They use a DID approach which has been previously recognized by other authors as the primary method to establish a causal relationship between alcohol and marijuana. According to the literature review on substitutability of marijuana and alcohol, DID method could be a very effective way of capturing marijuana legalization effect, since the model accounts for unmeasured time-invariant state-level features (Guttmannova et al., 2016). Dragone et al. (2018) used Oregon and Washington border county crime rate data prior 2012 and post 2012 (Washington recreational marijuana legalization year) to estimate a marijuana legalization effect. I add more states to the model and try to eliminate the already mentioned legalization spillover effect (Hao and Cowan, 2017). My aim is to investigate whether the implementation of marijuana legalization negatively affected alcohol consumption levels. The treatment year for medicinal marijuana legalization is 1998, so I

[14] According to Global Drinking Demographics study, beer consumption in the US is the largest, followed by spirits and wine, thus, my sample alcohol consumption correctly represents national alcohol consumption trend. Alcohol.org study used World Health Organization alcohol data.

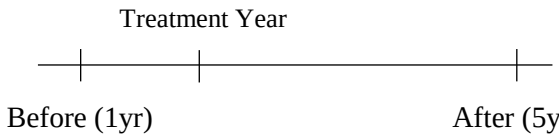
compare pre-legalization alcohol consumption level (1997) to post-legalization consumption level (1999):



(1)

The same method is used for the recreational marijuana analysis as well. There, my treatment year is 2012, thus, my pre- and post-consumption levels are measured at 2011 and 2013, respectively.

Literature fails to find significant long-term (five years and more) marijuana legalization effects. Anderson et al. (2013) found no significant differences four years after the implementation, even though short-term effects were significant. Cyclicality of alcohol use was observed two years after the legalization, meaning that, even if there were significant differences in alcohol consumption in the very short-term, the consumption rates for treatment and control groups converged back to status quo (Baggio, 2017). Therefore, I test my samples for the long-run differences in the alcohol consumption rates:



(2)

In the medicinal marijuana legalization estimation, I compare pre-legalization consumption level (1997) to post-legalization consumption level in the long-term (2003). For the recreational marijuana legalization estimation, I compare pre-legalization consumption level (2011) to post-legalization consumption level in the long-term (2016). Ideally for my model, I would need 2017 alcohol consumption level, unfortunately, that data was not available at the time of this project. Thus, my DID model equation is defined as:

$$Y = \beta_0 + \beta_1 D_{Tr} + \beta_2 D_{Post} + \beta_3 D_{Tr} D_{Post} + \beta_4 Race + \beta_5 Gender + \beta_6 Income + \beta_7 EdAt + \beta_8 Age + \varepsilon \quad (3)$$

Where D_{Tr} is a dummy variable indicating whether the state is control or treatment, D_{Post} is a dummy variable indicating whether the state consumption level is pre- or post-legalization, and $D_{Tr}\ D_{Post}$ is the interaction term between the first two dummy variables. The coefficient of the interaction term is the coefficient of interest, because it portrays the magnitude of difference between the differences of treatment and control states from pre- and post-legalization consumption levels in my sample. If the interaction term is significant and negative, my hypothesis that alcohol and marijuana are substitutes can be confirmed. The rest of my regression equation variables are explained in Table 4.

Having two term (short-term and long-term) estimations, for two different treatments (medicinal and recreational marijuana legalizations) and four different types of alcohol (beer, wine, spirits, "all drinks") led to sixteen total regressions.

5. Results

5.1 Medicinal Marijuana Legalization

The results from regressions 1-8 are represented in Tables 5 and 6. In the short-run, medicinal marijuana legalization did not result in significant differences (p-value > 0.05). The interaction term of "all drinks" regression is -0.028 (Table 5, Column 4), indicating that consumption of all drinks decreased by 0.028 gallons of ethanol per person, however, the coefficient was insignificant. Richer people drink less alcohol (p-value < 0.05), men drink more

alcohol (p-value < 0.05), white people drink less alcohol (p-value < 0.05), and older people drink more alcohol (p-value < 0.05) (Table 5, Column 4). Same interpretation of the results applies for all regressions. For all alcohol types, the interaction coefficient's sign varies, meaning that there was no clear direction of alcohol consumption change (Table 5).

Medicinal marijuana legalization in the long-term resulted in a negative change of alcohol consumption. The coefficients for beer, wine, spirits and "all drinks" are indicating decreases in alcohol consumption. The magnitude compared to the mean is relatively big for all the regressions (0.19 decrease of gallons of beer as compared to the mean of 1.35, etc.) Such a finding means that legalization of medicinal marijuana negatively affected alcohol consumption, but only the "all drinks" regression (8) interaction term was significant (p-value < 0.05) (Table 6, Column 4). After legalization of marijuana "all drinks" consumption per capita decreases by 0.276 gallons (Table 6). Non-white older males consume more beer and all drinks after the legalization (p-value < 0.05) (Table 6, Column 4).

5.2 Recreational Marijuana Legalization

Results from regressions 9-16 are reported in Tables 7 and 8. In the short-term, the interaction terms for all the alcohol categories are negative (yet insignificant), meaning that legalization of recreational marijuana leads to decreases in alcohol consumption one year after the implementation of the law (Table 7). The magnitude of all coefficients, except wine, is relatively big when compared to the mean alcohol consumed. An interesting finding is that, in general, alcohol consumption in the treatment states for all categories of alcohol, except spirits, is significantly lower (p-value < 0.05) (Table 7). Additionally, older uneducated people's alcohol consumption increases significantly (p-value < 0.01) with recreational marijuana legalization. It seems that race of the drinkers is an important factor, at least in the instances of wine, spirits and

"all drinks" consumption. White people are likely to drink more alcohol if recreational marijuana is legalized (p-value < 0.05) (Table 7, Columns 2, 3 and 4).

In the long-term, the interaction term for all the alcohol categories is negative, indicating that alcohol and marijuana are substitutes four years after the legalization. The magnitude of all coefficients, except wine, is relatively big, yet the results are insignificant (p-value > 0.05) (Table 8). Treatment states appeared to have significantly lower levels of alcohol consumption (p-value < 0.05) (Table 8). In addition, white, older uneducated people's spirit ethanol consumption increases significantly (p-value < 0.05) (Table 8).

6. Discussion

Legalization of marijuana has proved to increase the consumption of marijuana (Pacula, 2010). There are various second order effects that are believed to be influenced by the legalization of marijuana. Some of them include effects on real estate prices, opioid overdoses and Medicare expenses (more thoroughly discussed in section 2.6). The goal of this study was to examine the second order effect on alcohol consumption per capita. Specifically, the alcohol consumption patterns were examined using a DID model before and after legalization of marijuana. There is a substantial amount of literature discussing the relationship between the two goods. However, to this date, authors cannot reach a consensus as the results appear to be dependent on the model, methodology and data used. States that have already legalized either medicinal or recreational marijuana have been used as treatments states in comparison to the states that strictly prohibited any marijuana use. Regressions on medicinal marijuana legalization in the short-term (1-4) failed to provide definitive results as the signs of coefficients for different alcohol categories varied. Regressions on medicinal marijuana legalization in the long-term (5-8) indicated that medicinal marijuana legalization led to decreases in alcohol consumption. Particularly in the case of beer and

"all drinks" the magnitudes were relatively big. However, only the "all drinks" regression (8) was significant. Regressions on recreational marijuana legalization in the short-term (9-12) portrayed a negative relationship between marijuana and alcohol, however, the results were not significant. Regressions on recreational marijuana legalization in the long-term (13-16) portrayed a negative relationship between marijuana and alcohol, however, the results were, also, not significant. It is important to remember that recreational marijuana legalizations are very recent and too close to the present in order to estimate the most accurate effect.

Overall, there is less of a consistent evidence that there is a significant relationship between the drugs. According to my results, the relationship is ambiguous.

6.1 Policy Implications

Despite the insignificant, the coefficient signs suggest that there is some evidence of substitutability between alcohol and marijuana. Assuming that the results from this study pertained to the federal level and were reliable, it is possible to estimate the substitution effect in dollar terms from the perspective of an alcohol producer.[15] After medicinal marijuana legalization, the significant decrease of alcohol consumption per capita in the long-term is 0.276 gallons of ethanol (Table 6, Column 4). I multiply this number by the population (older than 14) size to convert it from per capita format. Then, it is important to determine the make-up of each alcohol category because this was the "all drinks" regression. I do that by looking at Constellation Brands 10-K statement and roughly estimate the proportion of each individual alcohol category from the official revenue report.[16] Thus, I was able to figure out the volume (gallons) decrease by multiplying by

[15] The authors of the dataset that is used in this project convert alcohol sales data into gallons of ethanol consumed per capita. I need to do the reverse.

[16] Constellation Brands 10-k was retrieved from https://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&CIK=0000016918&owner=exclude&count=40&hidefilings=0 Access date: 4/30/2019

the standard average alcohol level in beer, wine, and spirits.[17] The volume can then be converted into a decrease in numbers of boxes of alcohol.[18] From the 10-K report I estimated an average price of a box of specific beverage (sales/volume)[19]. Eventually, the result of medicinal marijuana legalization in the long-term led to an 11% decrease in alcohol industry revenues in five years. The statistic should be taken with a grain of salt; however, alcohol producers like Constellation Brands should consider the potential impact legalization of marijuana could have on alcohol demand. Including marijuana as one of its products is a great starting point for alcohol producers to secure themselves from losses, regardless of the true relationship between the two drugs. If they are complements, consumption of each substance would technically fuel the consumption of the other, increasing revenues.[20] If the substances are substitutes, alcohol providers would hedge their losses in alcohol related revenue with marijuana product revenues.

Other second order effects are also worth the consideration. State officials should closely pay attention to future research results as it has been proven that marijuana legalization leads to fewer healthcare costs. If marijuana has the potential to at least partially replace alcohol consumption, major health improvements can be attained by decreasing levels of binge drinking, life satisfaction and crime. Since there are many second order marijuana legalization effects, it is worth mentioning that food or cigarette industries should consider evaluating their good's relationship with marijuana. For marijuana producing companies, the United States is a market that has already opened its doors. Canada's blueprint and potential consequences of federal

[17] Individual standard alcohol levels were retrieved from https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/what-standard-drink Access date: 4/26/2019

[18] According to Constellation Brands reports, a box of beer is 24 cans of 12 ounce beers, where as a box of wine or spirit is 9 liters of the beverage.

[19] This is a very rough estimation since Constellation Brands is a higher tier alcohol producer.

[20] Companies should lower barriers to entry to increase revenue. I.e. increasing supply of marijuana would lower its cost which should result in more consumption of marijuana. More consumption of marijuana should lead to higher consumption of alcohol, leading to higher overall revenues.

marijuana legalization could suede the United States Administration to follow suit.[21] Therefore, preparing expansion strategies is paramount in order to cannibalize the potential market.

6.3 Robustness Check

To check whether the 11% decrease in potential alcohol revenue is probable, a robustness check was conducted. The absence of significant coefficients would at least verify that there is some negative relationship between marijuana and alcohol consumption. I used Regression 8 (Table 5, Column 4) and replaced Alaska, Oregon and Washington (treatment states) data with data of states that did not legalize medicinal marijuana. I randomly picked Utah, North Dakota and Kentucky. Everything else was kept the same. Unfortunately, the robustness check was significant (Table 9). It is an indication that the initial significance in my interaction term was not due to significant differences between treatment and control states, but rather because of a coincidence. The robustness check concluded that the results were not as robust as had been hoped for. The following section explores the caveats of this study.

6.3 Limitations

There are a several explanations for the results of my study. Since there is a lot of research with contradicting findings, it is possible that the relationship between the two goods is naturally ambiguous and context-dependent. Since alcohol consumption is a second order effect, the actual marijuana effect in its entirety might also be diffused. The fact that there are only ten states that have legalized marijuana to date complicate the methods of analysis. It is very difficult to select a sample of states that are theoretically identical with their only difference being marijuana laws.

[21] Retrieved from https://www.statnews.com/2019/03/22/canada-legalize-marijuana-lessons-united-states/ Access date: 4/26/2019

Ideally, federal legalization of marijuana and alcohol consumption data after that event would be required to accurately estimate the effect. The latest available alcohol consumption data ends in 2016, further limiting the possibility of completing a more detailed estimation since a lot of states have passed marijuana laws since January of 2016. As I only had access to crude, state-level data, the number of observations impaired the possibility of achieving robust results. More granular data (preferably county data) is required to estimate the accurate relationship. In addition, there are confounding factors that determine state alcohol consumption, besides access to marijuana. It is difficult to control for all the variables influencing alcohol consumption. States could simultaneously be implementing alcohol consumption laws to control alcoholism and binge drinking levels within the state. My study did not take into consideration state-specific alcohol tax related controls that could have changed in the period of my long-term estimation. In addition, states that legalize medicinal and recreational marijuana have different rules about possession and sales of the drug. Changes of specifications over the period of my estimation could have also influenced inaccurate results.

6.4 Future Research

My paper opens an opportunity to use more granular, county-level data for the specified states to increase the number of observations. An addition to this topic would be to contrast the effects of marijuana legalization between state-bordering county consumption levels and counties that are located as far as possible from each other. Thus, the spillover effect could be reaffirmed, and, if the results are similar, it would be clear that the spillover effect does not interfere with the estimation. Another way to account for the possible spillover effect is to focus on treatment and control counties that are located in the center of the state (farthest away from state border) because of the transportation costs. Lastly, many covariates could be added to one model to control for

other second order effects like crime rates (Dragone et al., 2018), taxes (Miller and Seo, 2019) and prices (Williams, 2004). As years go by, more data on alcohol consumption will be available from states that have just legalized marijuana. In a couple of years, Canadian alcohol consumption data will be useful to estimate the relationship between alcohol and marijuana on a federal level since its federal legalization in October of 2018. Contrasting state-level and federal-level analysis could bring more insights towards the ongoing debate.

7. Conclusion

Marijuana legalization has been one of the most controversial topics in the world. The debate has significantly intensified as a lot of people in Canada and United States have started to realize the potential benefits of legal marijuana. Past literature provides multiple studies in which marijuana legalization leads to significant second order effects. Notwithstanding, alcohol consumption is one of those effects that researchers cannot come to a consensus on. There is a substantial amount of evidence arguing for both complementarity and substitutability of the two goods, and this paper provides evidence that alcohol marijuana are substitutes, although not at a significant level. Even though there is an abundance articles related to this topic, this paper adds to the discussion by examining multiple state-level data and short-term as well as long-term effects of marijuana legalization on alcohol consumption. More analysis needs to be completed to gauge the true relationship between the two drugs which will be possible as official alcohol consumption data is released from new regions that have legalized marijuana.

Appendix

Year	State	Year	State
1996	California	2012	**Colorado, Washington**
1998	**Alaska, Oregon, Washington**	2014	Alaska, Oregon, Washington, DC
1999	Maine	2016	California, Maine, Massachusetts, Nevada, Vermont
2000	Colorado, Hawaii, Nevada		
2004	Montana, Vermont		
2006	Rhode Island		
2007	New Mexico		
2008	Michigan		
2010	Arizona, New Jersey, Washington, DC		
2011	Delaware		
2012	Connecticut, Massachusetts		
2013	Illinois, New Hampshire		
2014	Maryland, Minnesota, New York		
2016	Arkansas, Florida, North Dakota, Ohio, Pennsylvania		

Table 1: Timeline of State Marijuana Legalization Laws. Retrieved from https://www.thirdway.org/infographic/timeline-of-state-marijuana-legalization-laws

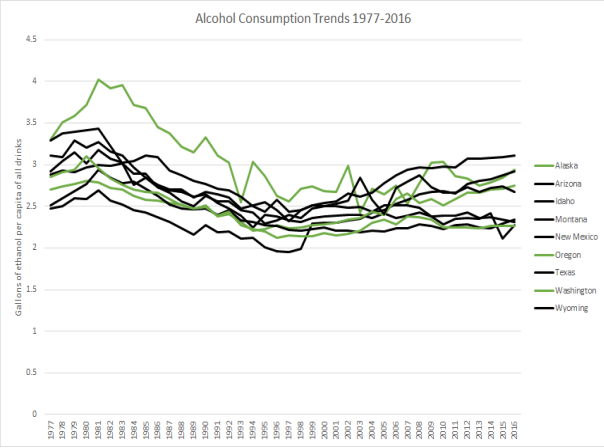


Figure 2: Medicinal Marijuana Legalization Sample Trends

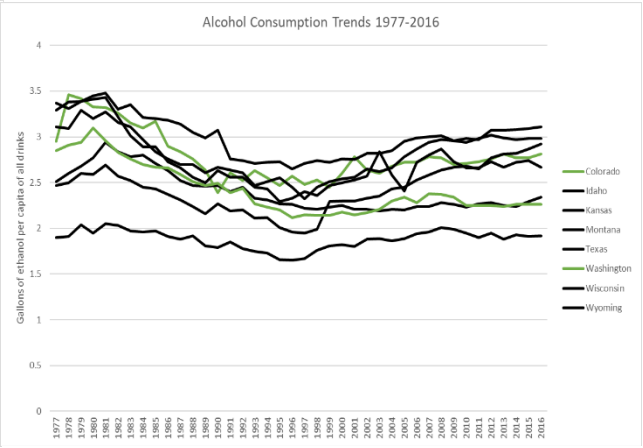


Figure 2: Recreational Marijuana Legalization Sample Trends

Control Group	(1)	(2)	(3)
VARIABLES	Obs	Mean	St. Dev.
Gallons of beer ethanol per capita	12	1.438	0.166
Gallons of wine ethanol per capita	12	0.298	0.125
Gallons of spirit ethanol per capita	12	0.642	0.129
Gallons of all drinks ethanol per capita	12	2.379	0.221
Tr	12	0	0
Post	12	0.500	0.522
Tr_Post	12	0	0
Educational Attainment (% of people older than 25 with a high school diploma)	12	0.818	0.0572
Gender Distribution (1 = male)	12	0.498	0.00374
Race Distribution (1 = white, 0 = non-white)	12	0.816	0.159
Age Ratio (% of people older than 20)	12	0.699	0.0163
Median Household Income	12	35,710	4,575
Treatment Group			
Gallons of beer ethanol per capita	6	1.188	0.0952
Gallons of wine ethanol per capita	6	0.422	0.0479
Gallons of spirit ethanol per capita	6	0.712	0.105
Gallons of all drinks ethanol per capita	6	2.325	0.154
Tr	6	1	0
Post	6	0.500	0.548
Tr_Post	6	0.500	0.548
Educational Attainment (% of people older than 25 with a high school diploma)	6	0.870	0.0399
Gender Distribution (1 = male)	6	0.504	0.0112
Race Distribution (1 = white, 0 = non-white)	6	0.814	0.0831
Age Ratio (% of people older than 20)	6	0.706	0.0269
Median Household Income	6	45,131	5,167

Table 2: Summary Statistics (Medicinal Marijuana Dataset)

Control Group	(1)	(2)	(3)
VARIABLES	Obs	Mean	St. Dev.
Gallons of beer ethanol per capita	12	1.265	0.233
Gallons of wine ethanol per capita	12	0.449	0.310
Gallons of spirit ethanol per capita	12	0.901	0.218
Gallons of all drinks ethanol per capita	12	2.614	0.418
Tr	12	0	0
Post	12	0.500	0.522
Tr_Post	12	0	0
Race Distribution (1 = white, 0 = non-white)	12	0.886	0.0475
Gender Distribution (1 = male)	12	0.500	0.00511
Median Household Income	12	54,448	4,693
Educational Attainment (% of people older than 25 with a high school diploma)	12	0.893	0.0391
Age Ratio (% of people older than 20)	12	0.723	0.0155
Treatment Group			
Gallons of beer ethanol per capita	4	1.067	0.121
Gallons of wine ethanol per capita	4	0.515	0.0208
Gallons of spirit ethanol per capita	4	0.933	0.200
Gallons of all drinks ethanol per capita	4	2.513	0.299
Tr	4	1	0
Post	4	0.500	0.577
Tr_Post	4	0.500	0.577
Race Distribution (1 = white, 0 = non-white)	4	0.844	0.0413
Gender Distribution (1 = male)	4	0.501	0.00201
Median Household Income	4	64,089	7,368
Educational Attainment (% of people older than 25 with a high school diploma)	4	0.903	0.00888
Age Ratio (% of people older than 20)	4	0.743	0.00891

Table 3: Summary Statistics (Recreational Marijuana Dataset)

Variable	Explanation
Race	Percentage of white people living in the state. 1 = white, 0 = non-white
Gender	Percentage of males living in the state. 1 = male, 0 = female
Income	Median household income
EdAt	Educational attainment. Percentage of state dwellers above 25 years old who have a high school diploma
Age	Percentage of people within the state who are older than 20

Table 4: Regression Variable Explanation

VARIABLES	(1) Beer Gallons PC	(2) Wine Gallons PC	(3) Spirit Gallons PC	(4) All Drinks Gallons PC
Tr	-0.0755	0.272	-0.0841	0.113
	(0.160)	(0.191)	(0.103)	(0.137)
Post	0.145	0.170	-0.141	0.175
	(0.137)	(0.164)	(0.0885)	(0.117)
Tr_Post	0.0244	-0.0998	0.0520	-0.0280
	(0.103)	(0.123)	(0.0664)	(0.0881)
Income	-2.20e-05	-4.66e-06	-5.81e-06	-3.20e-05**
	(1.28e-05)	(1.53e-05)	(8.24e-06)	(1.09e-05)
Gender	29.23**	-3.567	18.61**	44.81***
	(9.454)	(11.31)	(6.098)	(8.093)
Race	-0.879***	0.486	-0.465**	-0.852***
	(0.264)	(0.316)	(0.170)	(0.226)
Age	7.041**	-2.906	3.395*	7.690***
	(2.540)	(3.038)	(1.638)	(2.174)
EdAt	-1.353	-0.886	2.125*	-0.162
	(1.590)	(1.901)	(1.025)	(1.361)
Constant	-15.58**	4.520	-12.12***	-23.54***
	(5.100)	(6.101)	(3.290)	(4.366)
Observations	18	18	18	18
R-squared	0.819	0.478	0.875	0.880

Table 5: Regression Results (Medicinal & Short-run)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(5) Beer Gallons PC	(6) Wine Gallons PC	(7) Spirit Gallons PC	(8) All Drinks Gallons PC
Tr	-0.115	0.0938	-0.0412	-0.0556
	(0.143)	(0.153)	(0.0968)	(0.129)
Post	0.253*	-0.0177	-0.0474	0.184
	(0.122)	(0.130)	(0.0825)	(0.110)
Tr_Post	-0.190	-0.0385	-0.0324	-0.276**
	(0.120)	(0.128)	(0.0814)	(0.109)
Income	-1.74e-05	7.71e-06	-4.25e-06	-1.44e-05
	(1.17e-05)	(1.25e-05)	(7.93e-06)	(1.06e-05)
Gender	27.64**	-14.86	14.89*	27.84**
	(10.66)	(11.38)	(7.216)	(9.644)
Race	-0.870**	0.191	-0.260	-0.951***
	(0.289)	(0.308)	(0.196)	(0.261)
Age	7.856**	-3.111	3.640	8.444**
	(2.946)	(3.145)	(1.995)	(2.665)
EdAt	-1.508	1.483	1.199	1.278
	(1.547)	(1.652)	(1.047)	(1.400)
Constant	-15.39**	8.244	-9.916**	-17.25**
	(5.927)	(6.328)	(4.013)	(5.362)
Observations	18	18	18	18
R-squared	0.824	0.510	0.812	0.871

Table 6: Regression Results (Medicinal & Long-run)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(9) Beer Gallons PC	(10) Wine Gallons PC	(11) Spirit Gallons PC	(12) All Drinks Gallons PC
Tr	-0.490***	0.785**	0.0818	0.381**
	(0.140)	(0.302)	(0.107)	(0.160)
Post	-0.119	0.262	0.0819	0.228**
	(0.0779)	(0.168)	(0.0597)	(0.0894)
Tr_post	-0.0578	-0.00231	-0.0322	-0.0882
	(0.126)	(0.273)	(0.0967)	(0.145)
Income	4.15e-05**	-4.63e-05	-1.26e-05	-1.80e-05
	(1.52e-05)	(3.29e-05)	(1.17e-05)	(1.75e-05)
Gender	-13.22	-9.020	2.307	-18.78*
	(8.581)	(18.53)	(6.569)	(9.838)
Race	2.460	8.913**	6.632***	18.01***
	(1.736)	(3.749)	(1.329)	(1.990)
Age	11.36*	8.569	25.15***	44.99***
	(5.259)	(11.36)	(4.026)	(6.030)
EdAt	-6.116*	-9.694	-9.686***	-25.55***
	(2.747)	(5.933)	(2.103)	(3.150)
Constant	0.807	1.699	-15.10***	-13.04**
	(4.074)	(8.799)	(3.119)	(4.671)
Observations	16	16	16	16
R-squared	0.841	0.629	0.927	0.942

Table 7: Regression Results (Recreational & Short-run)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(13) Beer Gallons PC	(14) Wine Gallons PC	(15) Spirit Gallons PC	(16) All Drinks Gallons PC
Tr	-0.701**	0.474	-0.120	-0.343
	(0.215)	(0.312)	(0.119)	(0.343)
Post	-0.562**	0.240	-0.0349	-0.345
	(0.198)	(0.287)	(0.110)	(0.316)
Tr_Post	-0.347	-0.0419	-0.172	-0.557
	(0.234)	(0.339)	(0.129)	(0.373)
Income	7.09e-05**	4.82e-06	1.77e-05	9.27e-05**
	(2.26e-05)	(3.28e-05)	(1.25e-05)	(3.61e-05)
Gender	-12.37	-27.04	-7.151	-46.09*
	(15.07)	(21.85)	(8.345)	(24.06)
Race	-0.348	6.580	5.162**	11.41**
	(2.682)	(3.890)	(1.485)	(4.282)
Age	-0.608	-5.337	17.04***	11.18
	(7.455)	(10.81)	(4.129)	(11.90)
EdAt	-0.0932	-3.380	-5.807**	-9.413
	(4.096)	(5.940)	(2.268)	(6.539)
Constant	4.699	14.63	-8.171*	11.01
	(6.377)	(9.249)	(3.532)	(10.18)
Observations	16	16	16	16
R-squared	0.711	0.570	0.896	0.749

Table 8: Regression Results (Recreational & Long-run)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(17) All Drinks Gallons of Ethanol PC
Tr	0.0207
	(0.143)
Post	0.316*
	(0.158)
TrPost	-0.337**
	(0.147)
Age	11.04***
	(2.039)
Gender	57.28***
	(14.26)
Race	-1.391***
	(0.380)
EdAt	0.330
	(1.182)
Income	-2.53e-05
	(1.64e-05)
Constant	-32.28***
	(6.217)
Observations	18
R-squared	0.949

Table 9: Robustness Check Regression

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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